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# TECHNICIAN MANPOWER--REQUIREMENTS, RESOURCES, AND TRAINING NEEDS.

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TECHNICIANS ARE DEFINED IN THIS STUDY AS WORKERS WHO DIRECTLY OR INDIRECTLY SUPPORT SCIENTISTS AND ENGINEERS IN DESIGNING, DEVELOPING, PRODUCING, AND MAINTAINING THE NATION'S MACHINES AND MATERIALS. THIS REPORT PRESENTS THE RESULTS OF A COMPREHENSIVE STUDY OF CURRENT AND FUTURE TECHNICIAN MANPOWER CONDUCTED BY THE BUREAU OF LABOR STATISTICS WITH THE SUPPORT OF THE NATIONAL SCIENCE FOUNDATION. EMPHASIS IS PLACED ON THE TRAINING OF TECHNICIANS, PROJECTED SUPPLY AND DEMAND, PERSONAL AND EDUCATIONAL CHARACTERISTICS, AND THE NATURE OF THEIR WORK. IN 1963, THERE WERE APPROXIMATELY 845,000 TECHNICIANS EMPLOYED IN THE UNITED STATES, INCLUDING 439,000 IN ENGINEERING AND PHYSICAL SCIENCE, 232,000 DRAFTSMEN, 58,000 IN LIFE SCIENCE, AND 116,000 "OTHER" TECHNICIANS. THIS NUMBER IS EXPECTED TO RISE TO 1,500,000 IN 1975. GRADUATES OF POST-SECONDARY PREEMPLOYMENT CURRICULUMS ARE EXPECTED TO BE THE LARGEST AND MOST ADEQUATELY TRAINED SOURCE OF SUPPLY, WITH ABOUT 435,000 ENTERING TECHNICIAN JOBS FROM THESE PROGRAMS BETWEEN 1963 AND 1975. THIS DOCUMENT IS ALSO AVAILABLE AS GPO L2.3--1512 FOR 60 CENTS FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. (FS)

# Technician Manpower: Requirements, Resources, and Training Needs

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Bulletin No. 1512

UNITED STATES DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary

BUREAU OF LABOR STATISTICS
Arthur M. Ross, Commissioner

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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# Preface

This report presents the results of a major study of engineering and science technician manpower requirements and resources in 1975. The study was prepared in the Bureau of Labor Statistics, Office of Manpower and Employment Statistics, Harold Goldstein, Chief, with the support of the National Science Foundation.

The Bureau is grateful for the cooperation of the many interested persons who supplied information or who reviewed the draft of the study, and to the many industrial firms, schools, and associations that cooperated in the interview and review phases of the study. Their information provided valuable contributions to this report.

The report was prepared by Neal H. Rosenthal under the direction of Howard V. Stambler in the Bureau's Division of Manpower and Occupational Outlook, Sol Swerdloff, Chief. General direction from the National Science Foundation was provided by Robert W. Cain and Norman Seltzer. The research, interviewing, and analyses of data was conducted by Annie Lefkowitz, Gerard C. Smith, and Elaine Briccetti under the supervision of Sheldon H. Luskin.

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# Technician Manpower: Requirements, Resources, and Training Needs

## Summary and Highlights

This report presents the results of a comprehensive study of current and future technician manpower conducted by the Bureau of Labor Statistics with the support of the National Science Foundation. Emphasis is placed on the ways in which persons are trained for technician jobs, and on the projected supply and demand for these workers. Extensive information also is presented on the personal and educational characteristics of technicians and the nature of their work.

### Nature of Work

Despite the great importance of technicians to scientific and engineering teams, there is no generally accepted definition of the term "technician." One type of definition emphasizes education and training, indicating that technicians are those who have graduated from a 2-year technical institute or its equivalent. Another type of definition emphasizes the work performed by technicians, generally indicating that technician work falls between professional work done by scientists and engineers and skilled work done by craftsmen. The definition and concept of technicians used in this study are the same as those used in the Bureau of Labor Statistics surveys of scientific and technical personnel in private industry and State government. Accordingly, technicians are defined as workers who directly or indirectly support scientists and engineers in designing, developing, producing, and maintaining the Nation's machines and materials. Their work is technical in nature, but more limited in scope than the work of scientists and engineers, and has a practical rather than theoretical orientation. Excluded are medical and dental technicians who work with medical practitioners engaged in the care of patients.

Technicians may be classified into four major occupational groups according to the specialty or scientific discipline to which they are most closely related--draftsmen; engineering and physical science technicians; life science technicians; and "other" technicians, a miscellaneous group including industrial designers, computer programers, and surveyors. In 1963, there were approximately 845,000 technicians employed in the United States. Engineering and physical science technicians are the largest of the four groups, accounting for over one-half (439,000 in 1963) of all technicians. Draftsmen make up the second largest technician occupation, with about one-fourth of all technicians (232,000 in 1963). Life science technicians accounted for about 7 percent of all technicians (58,000) and "other" technicians, about 14 percent (nearly 116,000).

## Where Employed

Manufacturing industries employed about 390,000 technicians in 1963, primarily the electrical equipment, machinery, chemicals, fabricated metal products, and aircraft and parts industries. In private nonmanufacturing industries, large numbers of technicians were employed in engineering and architectural services (68,000), miscellaneous business services (39,000), and in the communications industry (29,000). Another large group was employed in government (170,000). Relatively few technicians were employed by colleges and universities and other nonprofit organizations.

## Characteristics

Technicians are a relatively young group of workers. According to estimates based on information in the Postcensal Study of Professional and Technical Manpower, the median age of employed technicians was about 33 years in 1963, as compared with about 43 years for all workers. There is little difference in the age distribution among the major occupational groups, although draftsmen tend to be slightly younger than other technicians.

Technicians have a relatively high level of educational attainment. The median number of school years completed by technicians employed in 1963 was estimated to be about 14 years, as compared with about 12 for all workers. Nearly 2 out of 3 technicians had some college education and 1 out of 10 had a bachelor's degree. Indications are that younger technicians have a higher educational level than their older counterparts.

## Training

Currently employed technicians have been trained in a variety of ways, ranging from formal programs in educational institutions to acquisition of skills through work experience in skilled occupations. Technician training can be classified into several broad types. One type is training designed specifically to prepare workers for technician jobs (preemployment occupational training). Such training is offered in secondary schools; post-secondary schools, such as technical institutes and junior colleges; company training programs; and in training programs sponsored by the Manpower Development and Training Act of 1962, as amended. Another method of preparing for technician work is through training or experience received during the course of education or training for other types of work, 4-year college and university bachelor's degree programs in science and engineering and in the Armed Forces. Gaining experience in a technician-related job is still another method of qualifying for technician work.

Approximately 90,000 persons entered the technician work force in 1963. The greatest number--estimated at about half of all new entrants--were upgraded from technician-related jobs. Of the nearly 40,000 persons entering technician jobs after completing a training program designed to prepare them for technician work, probably more than 20,000 acquired their skills in company training programs. Post-secondary school curriculums provided about 16,000 new graduates who entered technician jobs. Because government training programs only began in 1962, with the passage of the Manpower Development and Training Act, the number completing such programs in 1963 was small, although many technicians will receive their occupational training via this method in the future. Preemployment technician training in secondary schools is believed to be neither intensive nor extensive enough in most cases to prepare workers directly for technician jobs, although many such graduates will eventually enter such jobs after receiving additional technician training.

Of those new entrants to technician jobs in 1963 who qualified for their jobs through education or training received during preparation for other types of work, approximately 6,000 received training in colleges and universities, about half of whom received the bachelor's degree. The number of technicians entering directly after separation from Armed Forces technical jobs was small, despite the large number of persons with some technician training separated from the Armed Forces. However, many of those separated in 1963 are expected to enter technician jobs after receiving additional training, either in educational institutions or on the job.

## Requirements in 1975

The projections of requirements for technicians are based on a number of assumptions, including high levels of economic growth, continuation of scientific and technological advances, further increases in the complexity of industrial products and processes, and continued growth of research and development expenditures. Based on these assumptions, and using projections of industry manpower requirements developed in connection with a recent Bureau of Labor Statistics report, America's Industrial and Occupational Manpower Requirements, 1964-1975, technician manpower requirements are expected to increase by more than three-fourths over the 1963-75 period, rising from the 845,000 workers employed in 1963 to nearly 1,500,000 required in 1975.

In addition to about 650,000 technicians needed as a result of growth in requirements, about 380,000 will be needed to replace those employed in 1963 who will leave the occupation by 1975 as a result of retirements, deaths, and transfers to other occupations. Thus, total new technician manpower needs between 1963 and 1975 are projected at more than 1,025,000--an average of nearly 86,000 each year over the period.

To illustrate other possible demand conditions in 1975, alternative projections of requirements for technicians also are presented, based on different assumptions as to the factors affecting the demand for technicians. These alternate projections indicate total new technician manpower needs between 1963 and 1975 ranging from about 877,000 to nearly 1,300,000.

## Supply

Underlying the projections of the future supply of technicians are four key assumptions: (1) that employers prefer to hire new technicians who have completed a preemployment training program; (2) that funds allocated under recent Federal legislation to increase the facilities for technician training will be used for that purpose; (3) that current trends in the proportion of graduates of post-secondary preemployment training programs who enter technician jobs will continue in the future; and (4) that problems of status or salary will not deter young people from entering technician jobs any more or less than they have in the recent past. Based on these assumptions and others that are discussed in detail in the body of the report, the intermediate projections of the supply of technicians indicate that approximately 830,000 workers will enter technician jobs after completing some type of specialized technician training during the 1963-75 period.

Graduates of post-secondary preemployment curriculums are expected to be the largest source of supply, with about 435,000 entering technician jobs after completing these programs. Smaller numbers of technicians will enter from Government training programs, 4-year college and university curriculums, and the Armed Forces.

Not all those who enter technician occupations between 1963 and 1975 will still be in the field in 1975, the target year of the projections. For example, each year many newly trained technicians transfer to other occupations. Thus, of all new entrants over the 1963-75 period (including those from preemployment programs and from technician-related training in colleges and universities and in the Armed Forces), the net increase to supply in 1975 is estimated to be about 675,000, after allowing for deaths, retirements and transfers. To meet the need for the additional 350,000 technicians in 1975--and taking into account deaths, retirements, and transfers of new entrants--employers would have to upgrade about 425,000 workers over the 1963-75 period--an average of about 35,000 a year; this represents about one-third of all new entrants. Since, the number of technicians upgraded has averaged about one-half of all entrants in recent years, this amount of upgrading indicates an expected increase in the proportion of technicians with some type of specialized preparation for their job.

Alternative projections of the supply of technicians in 1975 also were developed to illustrate other assumptions concerning the determinates of supply. These alternative projections indicate a net supply of new technicians over the 1963-75 period (after deduction of personnel losses resulting from deaths, retirements, and transfers) ranging from 475,000 to nearly 1,040,000.

Relating these alternate projections of supply to the alternate projections of demand indicates a wide range of possible supply-demand conditions in 1975. Under any of the projected supply-demand situations, the demand for new entrants from post-secondary preemployment technician training programs is expected to exceed the number trained in this way. Thus, graduates of these programs are expected to have excellent employment opportunities. Opportunities should also be very good for those individuals interested in work as a technicians if they have some type of specialized training other than in post-secondary preemployment curriculums, including those with technician-related training in college and universities or in the Armed Forces and those without specialized training but engaged in technician-related work.

## Introduction

The requirements of an expanding and increasingly complex and technologically oriented economy have resulted in a growing emphasis on the need for technical workers of all kinds. Among these workers is a group who have gained widespread recognition in the past two decades as a vital part of the scientific and engineering team--technicians.

Although an increasing amount of attention has been directed toward engineering and science technicians in recent years, relatively little information is available about their personal characteristics, the nature of their work, and how they prepare for their jobs. Nor have the Nation's requirements, supply, and training needs for these workers been examined to the extent necessary to produce reliable information on future needs for and resources of technician manpower. This report attempts to provide some of this information. The information will be useful to vocational counselors of young people and others interested in choosing a field of work; 1/ to Government officials and others as an aid in assessing the adequacy of recent Federal legislation designed to encourage the training of technicians; and to industry officials as an additional source of information on how technicians can be employed to improve the utilization of their scientific and technical workers. The report also presents a detailed discussion of the methodology used in developing the projections for those with more technical interests.

To understand the projections of technician requirements and supply which appear in this study, several important points must be kept in mind. The most important of these is that the projections of requirements represent the Nation's needs for technicians in 1975, and not actual employment in that year. Another is that the projections of both requirements and supply are based on a set of explicit assumptions, which were viewed in mid-1965 as being likely to occur by 1975. 2/ To illustrate the influence and importance of the assumptions used, two alternative projections of both supply and demand were developed using different assumptions.

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1/ Information on technicians specifically designed to be used for the vocational guidance of young people may be found in "Employment Outlook for Technicians," Occupational Outlook Handbook, 1966-67 edition, (BLS Bulletin 1450), pp. 220-230.

2/ The general assumptions underlying the projections of requirements are presented on page 45 and those underlying supply on page 59. The detailed assumptions are presented throughout the report, where they specifically apply.

Another major point to be borne in mind is that the projections of requirements and supply were developed independently of each other, and without explicitly taking into account changes in the supply-demand relationship that might occur over the 1963-75 period. Should a large imbalance between the requirements for and the supply of technicians begin to appear during this period, both the supply and demand estimates would change accordingly. For example, if the demand for engineering and science technicians were to exceed the supply for any extended period of time, employers would tend to change their manpower utilization patterns in order to decrease their need for technicians; there most likely also would be increases in the supply of technicians as information on the favorable opportunities reached students, teachers, and counselors.

The projections of demand and supply are presented solely in quantitative terms, although manpower cannot be understood in these terms alone. Wide qualitative variations exist among workers in any occupation and particularly among technician occupations; no attempt has been made in this report to allow for the qualitative variations in workers.

In the course of the research for this bulletin, gaps and weaknesses in existing occupational data were encountered. For example, there are no completely reliable data on the number of technicians who transfer to other fields of work each year, and as a result, estimates of future requirements arising from these losses are rough approximations based on limited data. Because of these gaps and weaknesses, noted at various points in this report, the projections should be viewed only as indicators of the general magnitude of supply and demand in 1975, rather than as estimates of exact numbers.

Most of the statistics in the text and tables of this report are rounded to the nearest hundred for convenience in presentation and for ease of comparison; the rounding does not indicate that level of precision. In some instances, text data are rounded considerably, and thus may differ from data presented in tables.

# Chapter I. Nature of Work

Engineering and science technicians perform a wide and constantly changing variety of technical tasks. With the rapid advances in science and technology, the work of the technician has taken on new and even broader dimensions. This chapter presents a general discussion of the duties of technicians. In addition, it provides a discussion of the major duties of three clearly delineated groups of technicians--draftsmen, engineering and physical science technicians, life science technicians, and a miscellaneous group, "other technicians," composed of a variety of occupations, such as industrial designer, computer programer, and surveyor. 3/

## Definitional problems

The term "technician" has no generally accepted definition. It has been used by employers to refer to workers in a great variety of jobs, and doing a great variety of tasks. Many reasons underly the lack of a universally accepted definition. One major reason stems from the rapid growth of the occupation over the past two decades. As a result of the growth, accompanied by constantly changing job duties, technician occupations are described by several hundred job titles, many of which do not even include the term technician. 4/

Another important reason for the absence of a generally accepted definition is that different employers require persons in technician jobs to perform considerably dissimilar types of work or to have different levels of skill. For example, in some firms the "engineering technician" fabricates and assembles research equipment; in other firms the "engineering technician" designs this equipment. Thus, some duties performed by engineering and science technicians may overlap duties performed by skilled workers on the one hand, and scientists and engineers on the other. There is also a tremendous disparity among employers

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3/ Technicians who work with physicians, dentists, and other practitioners in the health fields and who are engaged in patient care are excluded from this study. In the remainder of the report, engineering and science technicians will be referred to simply as "technicians," in order to avoid confusion with the separate and distinct sub-categories "engineering technician" and "physical science technician."

4/ In the 1960 Census of Population Classification Index of Occupations and Industries (U.S. Bureau of the Census) over 350 job titles are listed in the engineering and science technician categories; in a study of more than 1,000 graduates of the technical institute program of Pennsylvania State University, graduates were employed in occupations with over 375 job titles. (See The Technical Institute, Leo F. Smith and Lawrence Lipsett, New York McGraw-Hill Book Company, 1956.) A study of Technical Occupations in New York State defines almost 200 different technical occupational groups. (See Technician Manpower in New York State, Vol. I New York State Department of Labor, December 1964.)

in the levels of training required of technicians. Some employers require their technicians to have technical institute or college training; others require little or no training beyond high school. 5/

As a result of the wide variations in the work performed, in the patterns of utilization, and in the educational level, there are marked differences in the approaches used to develop a definition of technicians, not only among employers, but also among educators and others concerned with technician manpower problems. One type of definition emphasizes education and training, and generally indicates that a technician must be a graduate of a two-year occupational curriculum, 6/ or have the equivalent in education or training. 7/

In another approach to the problem of defining technicians, emphasis is placed on the type of work performed. These definitions usually indicate that technician work falls somewhere between professional work done by scientists and engineers and skilled work done by craftsmen. 8/

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5/ Information on the educational attainment of technicians employed in 1963 is presented in chapter II. Employer educational requirements for technicians are also discussed in Technical Manpower in New York State, Vol. I and Vol. II, ibid.

6/ A description of technician occupational curriculums in 2-year schools is included in chapter III, which discusses the training of technicians. (See p. 35.)

7/ This basic approach has been taken by the Engineer's Council for Professional Development, 31st Annual Report for the Year Ending September 30, 1963; the U.S. Department of Health, Education, and Welfare, Office of Education, Division of Vocational Education, Area Vocational Education Programs, Administration of Title VIII, National Defense Education Act of 1958, P.L. 864, 85th Congress, Bulletin, Miscellaneous 3560, p. 9; G. Ross Henninger, The Technical Institute in America, McGraw-Hill Book Company, Inc., 1959, pp. 18-19; D.E. Irwin, "A Broad Industrial Concept of Technical Institutes and the Engineering Technician," Technical Education News, Special Issue, 1959, p. 10; and Syracuse Board of Education, Industrial Technicians for Greater Syracuse; 1960 p. 7.

8/ Among those who use this approach are the American Vocational Association, Inc., Definitions of Terms in Vocational, Technical, and Practical Arts Education, 1964, p. 20; the U.S. Department of Labor, Bureau of Employment Security, Technical Occupations in Research, Design, and Development Considered as Directly Supporting to Engineers and Physical Scientists, February 1961, p. 1-2; the New York State Department of Labor, op. cit.; and several other State agencies.

Within the many definitions, the workers covered include not only those who support scientists and engineers, but also a wide range of workers who perform different types of subprofessional duties, unrelated to science or engineering. For example, a Report of the Panel of Consultants on Vocational Education, requested by the President of the United States, 9/ includes as technicians many workers who do not support scientists and engineers, such as advertising copy writers, actuaries, credit analysts, and hotel housekeepers. Similarly, the American Association of Junior Colleges describes a "spectrum of middle-level manpower" made up of technician jobs in industry, the health fields, business-related technologies, agricultural scientific laboratory research, and public service. Within this "spectrum" are placed workers such as library assistants, legal secretaries, and PBX operator-receptionists. 10/

This report limits the scope of its coverage to engineering and science technicians, in order to make the analysis more manageable and more easily understood. It also provides only a general description of the work performed by technicians, rather than a detailed and explicit definition of who is or who is not a technician. Furthermore, in order to present technician requirements and supply, in the most meaningful fashion, technician descriptions utilize the parameter of the available employment statistics, primarily the occupational groups utilized by the Bureau of Labor Statistics in its continuing surveys of scientific and technical personnel. 11/ Thus, the overall category, engineering and science technician, is classified into four occupational categories: draftsman; engineering and physical science technician; life science technician; and "other" technician. Because the engineering and physical science technician group is by far the largest category, it is further subdivided into engineering technician, chemical technician, physics technician, mathematics technician, and "other" physical science technician. 12/

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9/ Education for A Changing World of Work, Appendix I, "Technical Training in the United States," U.S. Department of Health, Education, and Welfare, Office of Education, OE-80022, 1963, pp. 1-18.

10/ Norman C. Harris, Technical Education in the Junior College/New Programs for New Jobs, American Association of Junior Colleges, Washington, D.C., 1964, pp. 35-47.

11/ Employment of Scientific and Technical Personnel in Industry, 1962 (BLS Bulletin 1418, June 1964); Employment of Scientific and Technical Personnel in State Government Agencies, 1962 (BLS Bulletin 1412, 1964).

12/ The division of the engineering and science technician group was based on data appearing in the Postcensal Study of Professional and Technical Manpower. See p. for a brief discussion of the Postcensal Survey and appendix B for a discussion of the methodology used to estimate 1963 employment in the various occupational categories.

## Definition of Technician Work

As covered in this report, technicians directly or indirectly support scientists and engineers in designing, developing, producing, and maintaining machines and materials. In general, these technician jobs are technical in nature but more limited in scope than those of the engineer or scientist, and have a practical rather than a theoretical orientation. The following sections describe some of the duties performed by technicians covered in this report.

Many of these technicians help analyze and solve engineering and scientific problems by doing tasks such as making sketches and drawings; performing mathematical computations; and preparing formal reports on experiments, tests, and research projects. In addition, technicians may do manipulative work usually associated with the skilled trades, such as complicated and difficult soldering jobs. However, in contrast to the skilled craftsmen, whose job depends primarily upon his manipulative ability, the manipulative ability of the technician mainly aids him in applying scientific and technical knowledge to a particular technical problem. Frequently, these technicians use complex electronic and mechanical instruments, experimental laboratory apparatus, drafting instruments, tools, and equipment. Many use engineering handbooks and computing devices, such as the slide rule or calculating machine.

Technicians assist engineers and scientists in every phase of their work, often doing some of the tasks that would otherwise be done by scientists and engineers. Many technicians work in research, design, and development, usually working directly with or under the close supervision of a scientist or engineer. Technicians in research and development help conduct experiments or tests, often by setting up, calibrating, and operating sensitive instruments. Frequently, they help design, fabricate, and assemble experimental and testing equipment. Other technicians do drafting work and make extensive mathematical calculations. Those who engage in production operations do quality control, inspection, and testing; make time and motion studies; conduct liaison between engineering and production departments; and perform other related tasks. Technicians who work in installation, maintenance, and sales primarily sell technical products, install complex machinery and equipment, and provide technical services and advice directly to customers. One group of technicians--surveyors--provide information on the measurements and physical characteristics of construction sites, locate land boundaries, assist in setting land valuations, and collect information for maps, charts, and plats.

All technicians described in this report have one basic characteristic in common--they assist scientists or engineers, directly or indirectly. However, their duties differ sharply among the major occupational groups. The following descriptions of the work in several technician occupations are based on an analysis of many published descriptions and on interviews with representative employers of large numbers of technicians. Included are typical job titles for each occupation. 13/ Generic job titles which are widely used to identify technicians in several occupations are not listed in the discussion of each occupation. Such titles include laboratory helper, laboratory technician, laboratory assistant, research technician, junior engineer, and engineering aide.

Draftsmen. Draftsmen translate the ideas, rough sketches, specifications, and calculations of engineers, architects, and designers into exact working plans, using instruments such as compasses, dividers, protractors, and triangles, as well as machines that combine the functions of several instruments. Using drawings and specifications, they describe exactly what materials and processes are needed for a particular job.

The level of work performed by draftsmen ranges from routine tasks, such as tracing, to highly technical and complex design work. Senior draftsmen use the preliminary information provided by engineers and architects to prepare design "layouts" (drawings made to scale of the object to be built). They calculate the strength, quality, and cost of materials, using engineering handbooks and tables. Some draftsmen do independent designing or act as supervisors of other draftsmen, and assume the responsibility for starting and completing projects. Others, who are called detailers, make drawings of each part shown on the layout, giving dimensions, materials, and any other information necessary to make the detailed drawings clear and complete. Checkers carefully examine drawings for errors in computing or in recording dimensions and specifications. Tracers make corrections and prepare drawings for reproduction by tracing them on transparent cloth, paper, or plastic film. However, some of the more routine tasks performed by draftsmen in these latter jobs are being altered or eliminated by the advent of new drafting and reproduction equipment, and descriptions of these occupations should be reviewed constantly.

Practically all draftsmen specialize in a particular field of work. The largest fields are mechanical, electrical, structural, and architectural drafting. Typical job titles include mechanical draftsman, electrical draftsman, civil engineering draftsman, detailer, design engineer, instrument draftsman, and engineering draftsman.

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13/ For a listing of additional job titles included in various technician classifications, see Education for A Changing World of Work, op. cit., pp. 11-14, Technical Manpower in New York State, Vol. II, op. cit., and 1960 Census of Population Classification Index of Occupations and Industries, op. cit.

Engineering Technicians. 14/ Engineering technicians assist engineers in the application of basic scientific principles to the solution of practical engineering problems involved in creating a product or process. Engineering technicians usually specialize in one of the branches of engineering, such as aeronautical, civil, electrical,or mechanical engineering, and their specific duties and job titles usually vary according to the branch of engineering in which they specialize. A brief description of the work of technicians in a number of these areas of technology follows.

Aeronautical Technicians. Technicians specializing in aeronautical technology work with engineers in many phases of the design and production of aircraft, helicopters, rockets, missiles, and spacecraft. Many of these technicians aid engineers in preparing layouts of propulsion systems, aircraft and missiles structures, or equipment installations, by collecting information, making calculations, and performing many other tasks. Other technicians working on engineering projects prepare or check drawings for technical accuracy, practicability, and economy.

Technicians sometimes help estimate the cost of the materials and labor needed to manufacture aircraft and missiles. They also may be responsible for liaison between the engineers who do the planning and development work and the workers who convert the engineers' ideas into finished products. In liaison work, the technician compares an airplane or missile as it is being built with established specifications, keeps the engineer informed as to progress, and investigates any engineering related production problems that may arise. He may recommend minor changes in the design, the materials used, or the method of fabrication which would expedite production of parts of assemblies.

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14/ The term "engineering technician" as used in this report refers to technicians directly supporting engineers. Similar usage of this term is made by the American Society of Engineering Education (Characteristics of Excellence in Engineering Technology Education, 1962, p. 12), the National Society of Professional Engineers (NSPE) (The Certification of Engineering Technicians, December 1962), and the National Association of Manufacturers (NAM) (Your Opportunities in Industry as a Technician, April 1957, pp. 7 and 8.) However, other descriptions use "engineering technicians" more broadly to apply to technicians who work with scientists as well as engineers, including definitions developed by the Engineers Council for Professional Development (ECPD) (31st Annual Report for the Year Ending September 30, 1963), the President's Committee on Scientists and Engineers (Final Report to the President's Committee on Scientists and Engineers from the Working Committee for the Development of Supporting Technical Personnel, June 30, 1957, published January 15, 1958, pp. 2 and 3), the Panel of Consultants on Vocational Education (Education for A Changing World of Work), op. cit., and G. Ross Henninger (The Technical Institute in America, op. cit.)

Some aeronautical technicians are employed as manufacturers' field service representatives, serving as the link between the company and customers. Other technicians prepare instruction manuals, bulletins, catalogs, and other technical materials. Typical job titles of technicians specializing in aeronautical technology include instrument control technician, aircraft electronic mechanic, aircraft weight analyst, aircraft service coordinator, aircraft stress analyst, research propulsion test inspector, and liaison technician.

Civil Engineering Technicians. These technicians assist civil engineers in performing many of the tasks required in the planning and construction of highways, railroads, bridges, viaducts, dams, and other structures. During the planning stage, technicians may help in estimating costs, preparing specifications for materials, or participating in surveying, drafting, detailing, or designing work. Once the actual construction work has begun, they may assist the contractor or superintendent in scheduling construction activities or inspecting the work for conformance with blueprints and specifications. Typical job titles for civil engineering technicians include cost estimator, construction technician, construction specification writer, and highway inspector.

Electronic Technicians. Technicians in electronics technology include those working in radio, radar, sonar, telemetering, television, telephony, and other forms of communication; industrial and medical measuring, recording, indicating, and controlling devices; navigational equipment; missile and spacecraft guidance and control instruments; electronic computers; and many other types of equipment using vacuum tubes and semiconductor circuits. Because the field is so broad, technicians generally become specialists in one area--for example, communications--and often in a subdivision such as radio or radar. They also may specialize in some aspect of industrial electronics--for example, induction or dielectric heating, servomechanisms, automation controls, or ultrasonics.

Electronic technicians may prepare or interpret layouts and other diagrams, develop and test experimental electronic units, or assist scientists and engineers in the design of electronic circuits. Their work often calls for use of engineering handbooks, oscilloscopes, signal generators, ohmmeters, multitesters, and computing devices, such as slide rules.

Electronic technicians usually work in research, manufacturing operations, or maintenance and repair activities. Those in research usually assist engineers (or scientists) in designing, testing, and modifying experimental electronic devices. They may devise practical solutions to problems of design, select suitable materials, or test and evaluate the operating characteristics of the equipment after it is built. They may sometimes be assigned to make necessary modifications in experimental equipment.

Electronic technicians working in manufacturing operations may help engineers in designing and setting up different types of testing equipment and devising quality control and other tests for manufactured products. Electronic technicians doing maintenance and repair work need a high degree of technical knowledge. For example, electronic maintenance technicians employed by the Federal Aviation Agency keep radar and other electronic equipment in perfect working order for effective air traffic control. Electronics technicians may be employed in the engineering departments of radio and television broadcasting stations to operate and maintain the electronic equipment in the studio and at the transmitters.

Representative job titles for electronic technicians include communications technician, electronics specialist, electronics systems mechanic, electronics control technician, systems testing technician, electronic tube technician, electronic maintenance technician, and broadcast technician.

Industrial Engineering Technicians. Technicians in industrial technology assist industrial engineers with problems involving the efficient use of personnel, materials, and machines in the production of goods or services. They often are called production technicians as well as industrial technicians. Their work includes preparing layouts of machinery and equipment, planning the flow of work, and making statistical studies and analyses of production costs to eliminate unnecessary expense. The industrial technician also may assist the engineer by conducting studies that involve timing and analyzing the movements workers make. Typical job titles include, industrial technician, production analyst, production technician, methods systems analyst, production planner, time and motion study technician, and quality control technician.

Mechanical Engineering Technicians. Technicians in mechanical technology work in a large number of fields, including automotive technology, diesel technology, tool design, machine design, and production technology. Technicians working in these areas often assist engineers in design and development by making freehand sketches and rough layouts of proposed machinery and other equipment and parts. They help in determining whether a proposed machinery and product design change is practical. They also may attempt to solve particular design problems such as those involving tolerances, stress, strain, friction, and vibration.

A major area of work for mechanical technicians is carrying out tests on experimental machines and equipment for performance, durability, and efficiency. As part of the testing procedure, they record data, make computations, plot graphs, and analyze results, and write reports. They sometimes make recommendations for changes in design to meet performance requirements. Their jobs often require the use of instruments and other test equipment as well as the ability to prepare and interpret drawings.

Some workers having training in mechanical technology are employed in manufacturing to help develop plans for testing and inspecting machines and equipment, or to work with engineers in eliminating production problems. Others work as technical salesmen.

One specialist who may be classified as a mechanical engineering technician is the tool designer. He designs tools and devices for the mass production of manufactured articles. He originates and prepares sketches of the designs for cutting tools, jigs, dies, special fixtures, and other attachments used in machine operations. He also may make detailed drawings of these tools and fixtures, or supervise others in making them. Besides developing new tools, designers frequently redesign tools currently in use to improve their efficiency.

Typical job titles for mechanical engineering technicians include mechanical designer, automotive technician, tool designer, experimental technician, mechanical test technician, machine designer, experimental mechanic, and technical salesman.

Physical Science Technicians. Physical science technicians assist physical scientists and engineers in theoretical and applied research, and in solving practical problems. Generally, they work directly with physical scientists. 15/

Physical science technicians usually specialize in one branch of these sciences, usually chemistry, physics, or mathematics. 16/ In addition, a large number specialize in other physical science fields such as the earth sciences or metallurgy, or work in areas encompassing a combination of skills characteristic of several science disciplines. These other workers are designated in this report as "other" physical science technicians.

Chemical Technicians. Chemical technicians work mainly with chemists and chemical engineers in the development, production, sale, and utilization of chemical and related products. They apply their knowledge of the physical sciences to laboratory research or to work such as the control of complicated chemical processes. The field of chemistry is so broad that chemical technicians often become specialists in the problems of a particular industry, such as food processing, or in a particular activity, such as quality control.

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15/ There often are difficulties in identifying the occupational group in which a technician should be classified. For example, some technicians work both for a physical scientist and an engineer and could be classified as a physical science technician or an engineering technician.

16/ Although mathematics often is excluded from the physical sciences, mathematics technicians are here included in this broad category because of the nature of the statistics from which employment and other data were developed.

Most chemical technicians are engaged in research and development, testing, or other laboratory work. Those assisting chemists, other scientists, or engineers in conducting experiments may make the computations and tabulate and analyze the results. In doing testing work, they make chemical tests to determine whether the materials meet specifications or whether particular substances are present and if so in what quantities. They also perform experiments to determine the characteristics of substances, such as the specific gravity and ash content of oil. Technicians employed in research or testing laboratories often assemble and use apparatus and instruments such as dilatomers (which measure the dilation of expansion of a substance), analytical balances, and centrifuges.

Outside the laboratory, chemical technicians sometimes are employed to supervise various operations in the production of chemical products and as technical salesmen of chemicals and chemical equipment. Typical job titles of those in chemical technician occupations are assistant chemist, production control technician, quality control technician, chemical laboratory technician, chemical analyst, rubber technician, chemical control man, and food processing technician.

Physics Technicians. Physics technicians work closely with physicists in one of the several branches of physics such as atomic and molecular physics, nuclear physics, optics, or ultrasonics. Most physics technicians work in research and development, setting up and operating apparatus, maintaining laboratory facilities, and making calculations by using computing machines and slide rules. 17/ Examples of job titles of those in physics technician occupations are radiation technician, decontamination technician, nuclear technician, physics laboratory assistant, optical technician, health physics technician, and solid state technologist.

Mathematics Technicians. Mathematics technicians assist engineers, as well as mathematicians, by doing computations involving the use of algebra, logarithms, trigonometric functions and higher mathematics, usually in research. They may work with theoretical mathematicians, helping in experiments, analyzing raw scientific data, and recording and interpreting results. Mathematics technicians in applied mathematics assist mathematicians in the development of techniques for the solution of practical problems in the physical, biological, and social sciences. Some of their duties may involve the use of modern equipment. Representative job titles of those in mathematics technician jobs are mathematics aid, statistical assistant, data reduction technician, engineering weight computer, and weight control technician.

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17/ "Technical Assistants in Physics in the U.S.," Physics Today, March 1963, pp. 48-53.

Other Physical Science Technicians. A large number of physical science technicians specialize in many other areas, either in one of the physical sciences other than chemistry, physics, or mathematics, or in fields which encompass knowledge of several sciences.

Metallurgical technicians work with metallurgists and metallurgical engineers in processing metals, minerals, and ceramics and in examining these metals and alloys to determine physical properties. They also work in research laboratories on projects, for example, such as those seeking to develop new ways of treating and using metals and alloys. Typical job titles for metallurgical technicians include assistant metallurgist, metals laboratory technician, metals testing technician, and metallurgical engineering technician.

Instrumentation technicians work with engineers and scientists to develop, install, maintain, and use highly complex instruments that record data, control and regulate the operation of machinery, and make precise measurement of time, weight, temperature, speeds of moving parts, volume, flow, strain, pressure, and other characteristics. Representative job titles include aircraft development instrument technician, automated equipment technician, electronic instrument technician, test equipment technician, and computer laboratory technician.

Geological technicians assist geologists, other scientists, and engineers in the exploration and development of mineral and fuel resources. They may help collect, examine, and classify rocks, minerals, and fossils found at or near the surface of the earth, record data; and prepare geological maps. They also may assist professional workers in analyzing geological materials under controlled temperature and pressure, and performing other tasks needed for research on geological processes. Typical job titles are geologist helper, petroleum analyst, acid tester, gas tester, mining investigator, and oil laboratory analyst.

Meteorological technicians assist meteorologists in observing, measuring, recording, computing, processing, classifying, analyzing, verifying, and disseminating meteorological data. They help inspect and care for meteorological equipment, and use instruments which measure temperature, humidity, atmospheric pressure and wind velocity. They also may plot data on weather-maps, draw weather charts, and keep weather records. Typical job titles include map plotter, meteorological aide, meteorological equipment repairman, and weather observer technician.

Life Science Technicians. Included in the life science technician group are technicians engaged in tasks involving the study of life processes, and improvement of health and agricultural productivity. Three of the major life science technician occupations are agricultural technician, biological technician, and medical technician.

Agricultural Technicians. Agricultural technicians assist agricultural scientists in improving the quality of foods and soil conditions, and in developing and standardizing agricultural techniques and products. Under the supervision of scientists, they carry out experiments in agronomy, animal husbandry, or some other branch of agriculture. They assist in the investigation of the physical, chemical, and biological characteristics of soils; help establish and maintain conservation practices; revise farm plans; and gather data for use in the development of farm plans. Some examples of job titles are soils tester, agricultural equipment technician, livestock feed technician, fertilizer technician, and dairy and farm inspector.

Biological Technicians. Biological technicians assist biological scientists in the study of plants, animals, and microorganisms. They work with biological scientists in identifying and classifying plants; investigating bacteria, viruses, molds, and other organisms or microscopic or submicroscopic size; studying the orgins, classification, behavior, life processes, diseases, and parasites of animal life; and in using chemical methods to study the composition of biological materials and the molecular mechanism of biological processes. Representative job titles include biological aid, food technician, biochemistry technologist, food technician, animal technician, and primate technician.

Medical Technicians. Medical technicians assist doctors, dentists, pharmacists, and other life scientists engaged in clinical investigation and other research aimed at understanding diseases and improving health. They perform a wide variety of routine tests in one or more fields such as bacteriology, serology, parasitology, and hematology. In addition to performing routine laboratory tests, medical technicians may clean and sterilize laboratory equipment and prepare solutions following standard procedures. As mentioned previously, technicians who assist medical practitioners in the direct care of patients, in the dispensing of drugs and services, or in diagnoses are excluded from the technicians discussed in this report. Some typical job titles are medical aid, environmental health technician, biomedical technican, medical technologist, and medical laboratory assistant.

Other Technicians. In addition to the technicians previously described, there are other groups of technicians who work with scientists and engineers, including computer programers, surveyors, and industrial designers. [18]

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[18] The statistics presented later in this report on "other technicians" should be approached cautiously, and not used to represent data for a specific occupational category within this broad group. For example, data on the age distribution of other technicians discussed in chapter II should not be considered as the age distribution of surveyors or industrial designers, but as the age distribution for the combined group.

Computer Programers. Computer programers assist engineers, mathematicians, and other scientists in preparing instructions for electronic computers, checking on whether the instructions will produce the desired information, and revising instructions to eliminate difficulties that have appeared. Examples of job titles are computer analyst, computer process control technician, programing standards technician, and programing technician.

Surveyors. Surveyors determine the precise measurements and locations of elevations, points, lines, and contours on or near the earth's surface, and the distances between points. They record information disclosed by the survey; and make mathematical calculations based on such information; verify the accuracy of the survey data; and prepare sketches, maps, and reports. They provide information on the measurements and physical characteristics of sites, locate land boundaries, and assist in setting land valuations. Different branches and types of surveying require special techniques gained through experience or training, and surveyors may be designated by title according to the type of surveying work performed. Representative job titles include chief of parking, highway supervisor, licensed land surveyor, marine surveyor, and topographical photograph surveyor.

Industrial Designers. Industrial designers assist engineers and other professional personnel in designing machine-made products. In carrying out assignments, they use preliminary design sketches, notes, and design directives prepared by engineers, as well as their technical knowledge of materials, machines, and methods of production. Many are engaged in research and development, and help engineers design and construct experimental models of new products. Typical job titles include tool designer, layout designer, machine designer, and product designer.

## Chapter II. Employment and Personal Characteristics of Technicians

This chapter presents information on the employment and personal characteristics of technicians--their employer, education, age, sex, and other characteristics. The information is based primarily on data obtained from a follow-up survey of persons reporting themselves as technicians in the 1960 decennial Census enumeration, 19/ and from the Bureau of Labor Statistics surveys of scientific and technical personnel. 20/

### Employment

In 1963, the latest period for which data are available, there were about 845,000 technicians employed in the United States. (See chart 1.) 21/ Engineering and physical science technicians were the largest of the four major occupational groups, accounting for about half of all technicians. The second largest major occupational group was draftsmen, accounting for more than one-fourth of all technicians. Smaller proportions were employed as life science technicians (7 percent) and in a wide variety of other technician jobs (14 percent).

Within the engineering and physical science technician groups, by far the largest proportion (more than one-third of all technicians) were employed as engineering technicians. Smaller numbers were employed as chemical technicians, physics technicians, and mathematics technicians. About 6 percent of all technicians were in the "other physical science technician" category.22/

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19/ In this survey, known as the Postcensal Study of Professional and Technical Manpower, a large sample of persons who reported themselves as technicians in the 1960 Census were surveyed in 1962 in order to obtain data on their jobs, education, training, and other demographic, social, and economic data. The information on the 7 technician occupations included in the Postcensal Study--designers, draftsmen, electrical and electronic technicians, medical and dental technicians, other engineering and physical science technicians, surveyors, and technicians, not elsewhere classified--were analysed to develop occupational data that were comparable to the employment data developed in this report for the 4 major technician occupational groups. (See appendix B.)

20/ BLS Bulletins 1418 and 1412, op. cit.

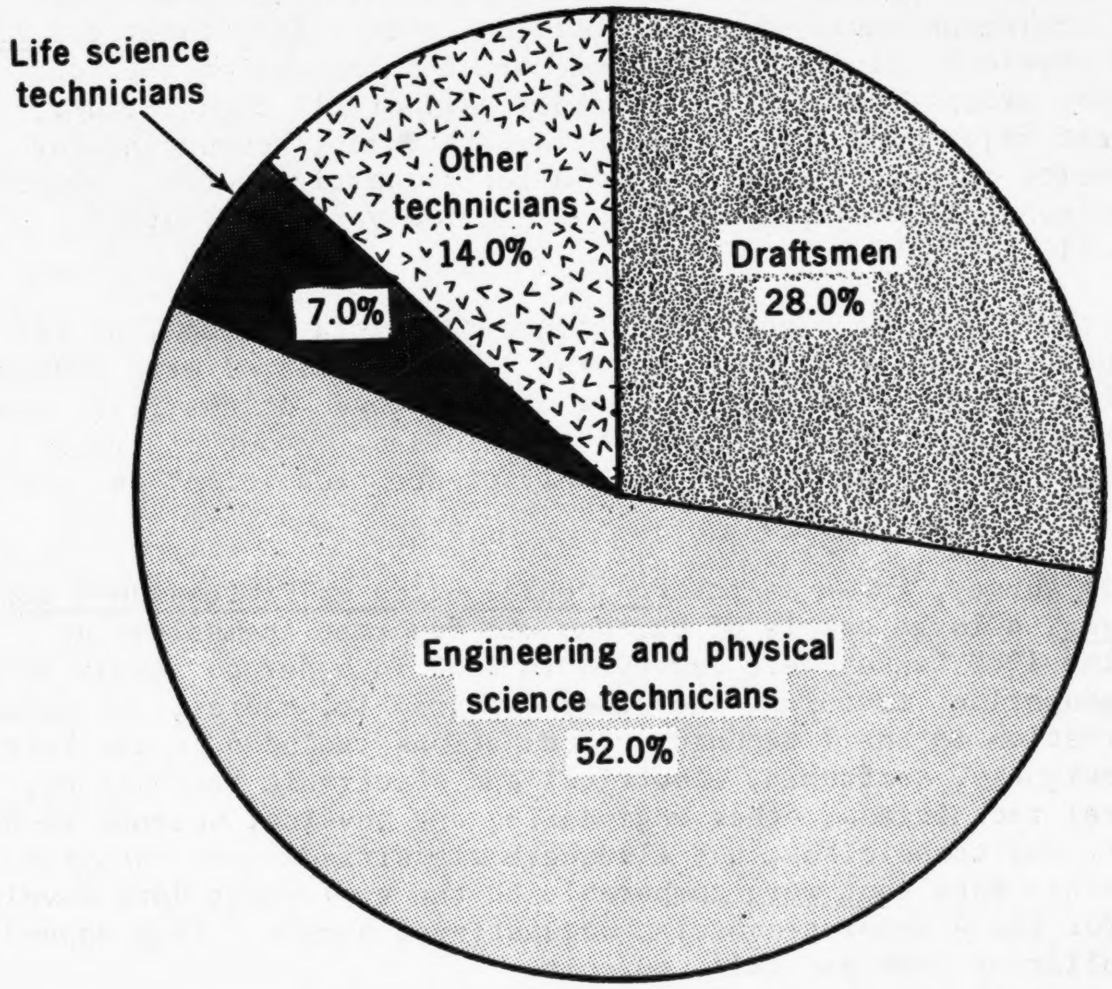
21/ Employment in the study refers only to civilian personnel. See appendix B for a description of the methodology and sources that were used to develop 1963 employment estimates.

22/ Included in the "other physical science technician" group are metallurgical technicians, instrumentation technicians, geological technicians, and meteorological technicians. (See p. 18.)

**Chart 1. ESTIMATED EMPLOYMENT OF TECHNICIANS, BY OCCUPATION, 1963**

**(Percent distribution)**

**Total employment = 844,800**



**Note: Because of rounding, the sum of parts may not add to totals.**

Manufacturing industries employed about 45 percent of all technicians in 1963. (See table 1.) The electrical equipment, machinery, chemicals and allied products, fabricated metals, and aircraft and parts industries accounted for two-thirds of the 390,000 employed in manufacturing. The heavy concentration of technicians in these industries reflects not only the high level of complexity of most of their products, but also their large amount of research and development activities. In nonmanufacturing industries, large numbers of industrial technicians are employed in the engineering and architectural services (68,000 in 1963), miscellaneous business services (39,000), and communications (29,000) industries. Other large numbers--170,000 in 1963--are employed in Government, mainly in Federal and State Government agencies. A relatively small number are employed by colleges and universities (10,000 in 1963) and by nonprofit organizations (13,000).

The industrial distribution of employment in individual technician occupations differs widely from the distribution of the total technician group. Nearly half of all engineering and physical science technicians were employed in manufacturing in 1963, whereas only about a seventh of all life science technicians were employed in this industry group. Government agencies employed about one-third of all life science technicians, but only about 1 in 10 draftsmen, and 1 in 4 engineering and physical science technicians.

## Education

Technicians have a relatively high level of academic training, according to estimates based on data from the Postcensal Study. 23/ The median number of school years completed by employed technicians was about 14 years in 1963 compared with about 12 years for all workers in the labor force. Nearly 2 out of 3 technicians had some college education, and 1 out of 10 technicians had a bachelor's degree. 24/ Only 1 out of 8 technicians had not completed high school.

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23/ Further information on the education attainment of technicians is presented in "Education and Training of Technicians," Monthly Labor Review, November 1964, pp. 1278-80.

24/ Of those technicians with some college but no bachelor's degree, only about 5 percent had the associate degree. However, the number of technicians with an associate degree may be slightly larger because some of those with a bachelor's degree probably earned the associate degree prior to the bachelor's degree.

Table 1. Estimated Employment of Technicians, by Occupation and Industry, 1963

| Industry | Total Technicians | Draftsmen | Engineering Technicians | Life Science Technicians | Other Technicians |
|---|---|---|---|---|---|
| All Industries | 844,800 | 232,000 | 439,000 | 58,100 | 115,700 |
| Mining (including petroleum) | 13,800 | 4,000 | 6,700 | 100 | 3,000 |
| Construction | 29,500 | 13,700 | 11,000 | 200 | 4,600 |
| Manufacturing | 389,700 | 122,800 | 207,500 | 8,900 | 50,600 |
| Ordnance and accessories | 19,300 | 4,500 | 12,800 | (1/) | 1,900 |
| Food and kindred products | 11,100 | 700 | 5,700 | 2,300 | 2,400 |
| Textile mill products and apparel | 2,900 | 300 | 1,500 | (1/) | 1,200 |
| Lumber and furniture | 9,000 | 4,300 | 1,600 | 400 | 2,700 |
| Paper and allied products | 6,400 | 2,000 | 3,400 | 100 | 900 |
| Chemicals and allied products | 38,400 | 3,300 | 24,500 | 4,300 | 6,200 |
| Petroleum refining and products of petroleum and coal | 6,700 | 1,100 | 4,200 | 100 | 1,400 |
| Rubber products | 5,500 | 1,400 | 3,000 | (1/) | 1,000 |
| Stone, clay, and glass products | 5,800 | 1,500 | 2,700 | (1/) | 1,500 |
| Primary metal products | 16,500 | 4,100 | 9,800 | 100 | 2,500 |
| Fabricated metal products | 26,300 | 16,700 | 6,600 | (1/) | 3,000 |
| Machinery, except electrical | 61,700 | 28,300 | 25,700 | 100 | 7,600 |
| Electrical equipment | 98,800 | 27,400 | 64,000 | 100 | 7,300 |
| Aircraft and parts | 35,200 | 9,000 | 22,300 | 100 | 3,800 |
| Motor vehicles and equipment | 13,500 | 6,100 | 5,200 | 100 | 2,100 |
| Other transportation equipment | 6,700 | 4,500 | 1,900 | (1/) | 300 |
| Professional and scientific instruments | 20,600 | 5,200 | 10,800 | 900 | 3,700 |
| Miscellaneous manufacturing | 5,400 | 2,500 | 1,800 | 100 | 1,100 |
| Transportation, communication, and electric, gas, and sanitary services | 55,200 | 7,900 | 37,200 | 300 | 9,900 |
| Transportation | 8,200 | 2,100 | 3,900 | 100 | 2,100 |
| Communication | 29,200 | 800 | 23,500 | (1/) | 4,900 |
| Electric, gas, and sanitary services | 17,900 | 5,000 | 9,900 | 200 | 2,900 |
| Other industries | 176,800 | 59,300 | 66,700 | 25,500 | 35,300 |
| Miscellaneous business services | 39,100 | 11,300 | 20,300 | 1,100 | 6,400 |
| Medical and dental laboratories | 16,200 | (1/) | (1/) | 15,800 | 400 |
| Nonprofit organizations | 13,100 | 1,600 | 7,900 | 3,600 | 100 |
| Engineering and architectural services | 68,200 | 43,300 | 11,500 | (1/) | 13,400 |
| All other nonmanufacturing | 40,100 | 3,100 | 27,000 | 5,000 | 5,000 |
| Government | 169,800 | 22,300 | 105,700 | 19,500 | 22,300 |
| Federal Government | 78,700 | 5,500 | 54,700 | 13,300 | 5,200 |
| State governments | 59,400 | 6,500 | 31,700 | 5,500 | 15,700 |
| Local governments | 31,600 | 10,300 | 19,300 | 700 | 1,400 |
| Colleges and universities | 10,000 | 2,000 | 4,300 | 3,700 | 100 |

1/ Less than 50 cases.

Note: Because of rounding, the sum of individual items may not equal totals.

Source: Bureau of Labor Statistics

A comparison of the level of educational attainment of the individual technician specialties reveals some marked differences. (See table 2.) For example, nearly 3 out of 4 draftsmen had some college, as compared with about 3 out of 5 of those in each of the other technician occupational groups. More than 1 in 5 life science technicians had a bachelor's degree or higher, as compared with 1 in 14 draftsmen with this level of education. Similarly, only 7 percent of all draftsmen had less than a high school education, whereas about 15 percent of the engineering and physical science technicians and other technicians, and 13 percent of the life science technicians failed to complete high school.

The growing educational attainment of technicians is illustrated by the fact that younger technicians have completed more schooling than older technicians. (See table 3.) About two-thirds (65 percent) of those 24 years of age or less had completed at least some college work, as contrasted with only about 45 percent of those age 55 or older. 25/ Less than 6 percent under 25 years of age reported that they had not completed high school, as compared with about 43 percent 55 years of age or older. Although educational attainment differs among the various technician occupational groups, the differences apparently are attributable to age rather than occupational specialty.

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25/ Although, as illustrated previously, only 5 percent of those technicians with some college training but no bachelor's degree did have an associate degree, the growing importance of the associate degree is evidenced by the fact that about 10 percent of those 20 to 24 years old with some college training but no bachelor's degree had the associate degree, as compared with less than 1 percent of those aged 45 or older. As mentioned previously, some of the older technicians with a bachelor's degree may have earned the associate degree prior to receiving the bachelor's degree, however, the difference in the proportion having the associate degree in younger age groups is still significant.

Table 2. Level of Education of Technicians, by Occupation, 1963

| Education distribution | All technicians |  | Draftsmen |  | Engineering and physical science technicians |  | Life science technicians |  | Other technicians |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| All levels---- | 844,000 | 100.0 | 232,000 | 100.0 | 439,000 | 100.0 | 58,100 | 100.0 | 115,700 | 100.0 |
| Less than high school---- | 103,400 | 12.2 | 15,500 | 6.7 | 63,700 | 14.5 | 7,400 | 12.7 | 16,800 | 14.5 |
| High school graduate------- | 208,100 | 24.6 | 50,100 | 21.6 | 113,300 | 25.8 | 16,400 | 28.2 | 28,300 | 24.5 |
| Some college 1/- | 448,600 | 53.1 | 149,600 | 64.5 | 223,900 | 51.0 | 21,900 | 37.7 | 53,200 | 46.0 |
| Bachelor and bachelor plus-- | 84,200 | 10.00 | 16,700 | 7.2 | 38,200 | 8.7 | 12,100 | 20.9 | 17,200 | 14.9 |
| Other 2/-------- | 400 | (3/) | --- |  | --- | --- | 300 | .5 | 100 | .1 |

1/ Includes technicians without any degree and those with an associate degree but no bachelor's degree.

2/ Registered nurses.

(3/) Less than 0.05 percent.

Note: Because of rounding the sum of individual items may not equal totals.

Source: Based on information in the Postcensal Study of Professional and Technical Manpower.

## Table 3. Level of Education of Technicians by Occupation and Age, 1963
(Percent distribution)

| Age Distribution | All levels of education | | Less than high school | High school graduates | Some college 1/ | Bachelor and plus | other 3/ |
|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | |
| | **All technicians** | | | | | | |
| All ages ------ | 844,800 | 100.0 | 12.2 | 24.6 | 53.1 | 10.0 | (2/) |
| Less than 20 years- | 14,200 | 100.0 | 7.6 | 29.7 | 62.6 | -- | -- |
| 20-24 years ----- | 159,000 | 100.0 | 3.8 | 29.4 | 62.6 | 4.3 | -- |
| 25-34 years ----- | 296,900 | 100.0 | 6.7 | 22.4 | 58.6 | 12.3 | -- |
| 35-44 years ----- | 212,400 | 100.0 | 11.8 | 25.8 | 52.2 | 10.2 | -- |
| 45-54 years ----- | 107,500 | 100.0 | 21.8 | 26.5 | 41.7 | 9.9 | -- |
| 55-64 years ----- | 43,200 | 100.0 | 44.1 | 9.1 | 34.5 | 11.6 | .7 |
| 65 and over ----- | 11,400 | 100.0 | 41.2 | 11.8 | 35.6 | 11.4 | -- |
| | **Draftsmen** | | | | | | |
| All ages ------- | 232,000 | 100.0 | 6.7 | 21.6 | 64.5 | 7.2 | -- |
| Less than 20 years- | 3,200 | 100.0 | -- | 28.8 | 71.2 | -- | -- |
| 20-24 years ----- | 51,300 | 100.0 | 2.3 | 30.7 | 65.4 | 1.6 | -- |
| 25-34 years ----- | 80,300 | 100.0 | 2.5 | 20.5 | 66.6 | 10.5 | -- |
| 35-44 years ----- | 57,100 | 100.0 | 4.6 | 19.5 | 69.0 | 6.9 | -- |
| 45-54 years ----- | 26,200 | 100.0 | 13.8 | 18.8 | 58.6 | 8.7 | -- |
| 55-64 years ----- | 9,300 | 100.0 | 43.0 | 5.0 | 42.5 | 9.5 | -- |
| 65 and over ----- | 4,600 | 100.0 | 45.4 | 9.5 | 35.9 | 9.2 | -- |
| | **Engineering and physical science** | | | | | | |
| All ages ------- | 439,000 | 100.0 | 14.5 | 25.8 | 51.0 | 8.7 | -- |
| Less than 20 years- | 6,100 | 100.0 | 12.6 | 49.5 | 37.9 | -- | -- |
| 20-24 years ----- | 78,600 | 100.0 | 5.3 | 27.9 | 63.5 | 3.4 | -- |
| 25-34 years ----- | 164,600 | 100.0 | 9.3 | 21.6 | 58.7 | 10.5 | -- |
| 35-44 years ----- | 109,300 | 100.0 | 14.7 | 31.8 | 45.0 | 8.5 | -- |
| 45-54 years ----- | 57,900 | 100.0 | 28.2 | 27.4 | 33.8 | 10.5 | -- |
| 55-64 years ----- | 19,300 | 100.0 | 51.9 | 10.1 | 25.5 | 12.6 | -- |
| 65 and over ----- | 3,100 | 100.0 | 39.2 | 14.0 | 32.7 | 14.1 | -- |

See footnotes at end of table.

Table 3. Level of Education of Technicians by Occupation and Age, 1963
(Percent distribution) - Continued

| Age Distribution | All levels of education | | Less than high school | High school graduates | Some college 1/ | Bachelor and plus | Other 3/ |
|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | |
| | **Life science technicians** | | | | | | |
| All ages ------- | 58,100 | 100.0 | 12.7 | 28.2 | 37.7 | 20.9 | .5 |
| Less than 20 years - | 2,100 | 100.0 | -- | -- | 100.0 | -- | -- |
| 20-24 years ----- | 11,600 | 100.0 | -- | 27.2 | 49.7 | 23.1 | -- |
| 25-34 years ----- | 15,700 | 100.0 | 2.9 | 20.1 | 37.4 | 39.6 | -- |
| 35-44 years ----- | 16,800 | 100.0 | 25.2 | 25.2 | 33.8 | 15.6 | -- |
| 45-54 years ----- | 6,600 | 100.0 | 6.7 | 73.3 | 13.3 | 6.8 | -- |
| 55-64 years ----- | 4,200 | 100.0 | 51.5 | 11.9 | 23.6 | 6.3 | 6.3 |
| 65 and over ----- | 900 | 100.0 | -- | 47.1 | 52.9 | --- | -- |
| | **Other technicians** | | | | | | |
| All ages ------- | 115,700 | 100.0 | 14.5 | 24.5 | 46.0 | 14.9 | .1 |
| Less than 20 years - | 2,800 | 100.0 | 9.9 | 16.8 | 73.3 | -- | -- |
| 20-24 years ------ | 17,500 | 100.0 | 4.3 | 29.7 | 56.4 | 9.5 | -- |
| 25-34 years ------ | 36,300 | 100.0 | 7.8 | 25.9 | 47.8 | 18.5 | -- |
| 35-44 years ------ | 29,200 | 100.0 | 15.1 | 23.3 | 44.0 | 17.7 | -- |
| 45-54 years ------ | 16,800 | 100.0 | 22.0 | 29.5 | 36.9 | 11.6 | -- |
| 55-64 years ------ | 10,400 | 100.0 | 38.7 | 10.1 | 37.1 | 13.0 | 1.1 |
| 65 and over ------ | 2,800 | 100.0 | 36.0 | 13.3 | 35.2 | 15.5 | -- |

1/ Includes technicians without any degree and those with an associate degree but no bachelor's degree.

2/ Less than 0.05 percent.

3/ Registered nurses.

Note: Because of rounding the sum of individual items may not equal totals.
Source: Based on information in Postcensal Study of Professional and Technical Manpower.

## Age

Engineering and science technicians are younger, on the average, than workers in the professional, technical, and kindred worker (PTK) group, 26/ or than all workers as a whole. The median age of employed technicians was about 33 years in 1963, compared with a median age of about 41 years for the overall PTK category, and 43 years for all workers. More than 75 percent of all technicians were under 45 years in 1963 (as compared with about 65 percent of the total number of employed workers) and 55 percent were less than 35 years old.

There is little difference in the age distribution among the major technician occupational groups, although draftsmen tend to be slightly younger than other technicians. Estimated median ages in 1963 ranged from 33 years for draftsmen and engineering and physical science technicians, to 35 years for "other" technicians. The proportion and the number in various age groupings, by occupation is shown in table 4.

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26/ Within the major occupation groupings used to classify all workers, technicians are classified in the professional, technical, and kindred worker group.

Table 4. Estimated Age Distribution of Technicians, by Occupation, 1963

| | All technicians | Draftsmen | Engineering and physical science technicians | Life science technicians | Other technicians |
|---|---|---|---|---|---|
| | | | Number | | |
| All ages---------- | 844,800 | 232,000 | 439,000 | 58,100 | 115,700 |
| Less than 20 years-- | 14,200 | 3,200 | 6,100 | 2,100 | 2,800 |
| 20-24 years-------- | 159,000 | 51,300 | 78,600 | 11,600 | 17,500 |
| 25-34 years-------- | 296,900 | 80,300 | 164,600 | 15,700 | 36,300 |
| 35-44 years-------- | 212,400 | 57,100 | 109,300 | 16,800 | 29,200 |
| 45-54 years-------- | 107,500 | 26,200 | 57,900 | 6,600 | 16,800 |
| 55-64 years-------- | 43,200 | 9,300 | 19,300 | 4,200 | 10,400 |
| 65 and over-------- | 11,400 | 4,600 | 3,100 | 900 | 2,800 |
| | | | Percent | | |
| All ages---------- | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Less than 20 years-- | 1.7 | 1.4 | 1.4 | 3.7 | 2.4 |
| 20-24 years-------- | 18.8 | 22.1 | 17.9 | 20.0 | 15.1 |
| 25-34 years-------- | 35.2 | 34.6 | 37.5 | 27.0 | 31.4 |
| 35-44 years-------- | 25.1 | 24.6 | 24.9 | 29.0 | 25.2 |
| 45-54 years-------- | 12.7 | 11.3 | 13.2 | 11.4 | 14.5 |
| 55-64 years-------- | 5.1 | 4.0 | 4.4 | 7.3 | 9.0 |
| 65 and over-------- | 1.4 | 2.0 | 0.7 | 1.6 | 2.4 |

Note: Because of rounding the sum of individual items may not equal totals.
Source: Based on information in the Postcensal Study of Professional and Manpower.

## Sex

In 1963, less than 10 percent of all employed technicians were women. (See table 5.) The proportion of women varied considerably by occupation, ranging from nearly 4 percent of draftsmen to over 25 percent of the life science technicians.

Table 5. Estimated Employment of Technicians by Sex and Occupation, 1963

| | All technicians | Drafts-men | Engineering and physical science technicians | Life science technicians | Other technicians |
|---|---|---|---|---|---|
| | Number | | | | |
| Total... | 844,800 | 232,000 | 439,000 | 58,100 | 115,700 |
| Male....... | 767,700 | 223,400 | 401,700 | 42,500 | 100,100 |
| Female..... | 77,100 | 8,600 | 37,300 | 15,600 | 15,600 |
| | Percent | | | | |
| Total... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Male....... | 90.9 | 96.3 | 91.5 | 73.2 | 86.5 |
| Female..... | 9.1 | 3.7 | 8.5 | 26.8 | 13.5 |

Note: Because of rounding the sum of individual items may not equal totals.
Source: Based on information in the Postcensal Study of Professional and Technical Manpower.

The educational attainment of male and female technicians differs significantly. About 18 percent of all women technicians had the bachelor's degree or more, whereas only about 10 percent of the males reached this level of education. (See table 6.) At the other end of the scale, 16 percent of the female workers did not have a high school diploma, whereas only about 12 percent of the males did not complete high school training. A greater proportion of men had some college education, but no bachelor's degree (56 percent of all men technicians and 32 percent of all women technicians).

The education distribution for men and women in each of the 4 major technician occupational groups generally followed the pattern of the overall technician group. However, there were significant differences in the life science technician group. In this group, the proportion of women having a bachelor's degree or more was very large, 31 percent, and only about 6 percent of the females did not have a high school diploma. For male life science technicians, the proportions were 17 percent and 15 percent, respectively.

Table 6. Employment of Technicians, by Educational Level and Sex, 1963
(Percent distribution)

| | All technicians | Draftsmen | Engineering and physical science technicians | Life science technicians | Other technicians |
|---|---|---|---|---|---|
| Total | | | | | |
| All education levels: Number | 844,800 | 232,000 | 439,000 | 58,100 | 115,700 |
| Percent | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Less than high school-------- | 12.3 | 6.7 | 14.5 | 12.7 | 14.5 |
| High school graduate---------- | 24.7 | 21.6 | 25.8 | 28.2 | 24.5 |
| Some college 1/----- | 52.9 | 64.5 | 51.0 | 37.7 | 46.0 |
| Bachelor's or more-- | 10.1 | 7.2 | 8.7 | 20.9 | 14.9 |
| Other 2/------------ | (3/) | --- | --- | .5 | .1 |
| Male | | | | | |
| All education levels: Number | 767,700 | 232,000 | 401,700 | 42,500 | 100,100 |
| Percent | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Less than high school-------- | 11.5 | 6.5 | 13.8 | 15.3 | 14.2 |
| High school graduate---------- | 23.3 | 20.7 | 24.7 | 30.3 | 24.1 |
| Some college 1/----- | 55.7 | 65.7 | 53.3 | 37.2 | 47.2 |
| Bachelor's or more-- | 9.5 | 7.2 | 8.2 | 17.2 | 14.4 |
| Other 2/------------ | --- | --- | --- | --- | --- |
| Female | | | | | |
| All education levels: Number | 77,100 | 8,600 | 37,300 | 15,600 | 15,600 |
| Percent | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Less than high school-------- | 16.2 | 12.5 | 21.6 | 5.6 | 16.1 |
| High school graduate---------- | 33.0 | 45.4 | 37.5 | 22.6 | 26.7 |
| Some college 1/----- | 32.7 | 34.5 | 27.0 | 39.1 | 38.5 |
| Bachelor's or more-- | 17.5 | 7.7 | 13.9 | 30.9 | 17.9 |
| Other 2/------------ | .5 | --- | --- | 1.8 | .7 |

1/ Includes technicians without any degree and with those with an associate degree but no bachelor's degree.

2/ Registered nurses.

3/ Less than .05 percent.

Note: Because of rounding, the sum of individual items may not equal sum of totals.

Source: Based on information in the Postcensal Study of Professional and Technical Personnel.

## Chapter III. Training of Technicians

Today's technician workforce acquired its skill in many ways, ranging from gradual acquisition of skills while working in a technician-related occupation to completion of a formalized program of instruction in an educational institution. Some technicians took training with the specific intention of preparing for a technician job; others received training in the course of preparation for another job. This chapter discusses in detail the major ways in which technicians qualify for their jobs. 27/ It describes the various sources of training and presents the primary objectives of the programs. The chapter also presents estimates of the number of persons who received training in 1963 from each of these sources and entered a technician job in that year. 28/

It should be emphasized that the relative importance of specific types of training cannot be evaluated simply in terms of the number of people taking such training. As will be shown in chapter V, the proportion of those taking training who actually enter technician jobs differs considerably by type of training. Also, persons in technician occupations usually state that more than one kind of training prepared them for their jobs. 29/ For example, many technicians have had both technician training in post-secondary schools and industrial technician training. In such cases, the ability to perform technician work depends to a great extent on the sum total of the training and experience obtained. Furthermore, employers often hire technicians for entry jobs with a level of training below that which they would prefer and then train them on the job. For example, in a study of technician manpower conducted by the New York State Department of Labor, the proportion of college and technical institute graduates employed in technician jobs was below the proportion that employers prefered to employ. 30/

An analysis of current trends in technician training also is important in evaluating the effectiveness of training methods. For example, although it is estimated that more technicians learned to perform their jobs through

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27/ The discussion of the level of training attained by technicians in 1963 presented in shapter II indicates educational attainment rather than the training that was directly responsible for the workers entrance into a technician job. For example, a technician with the bachelor's degree may have been working as a technician for several years while attending college. Data are not available to develop estimates of the proportion of all technicians in the 1963 labor force who entered their jobs directly from each of the various methods of training.

28/ Projections of entrants over the 1963-75 period are discussed in chapter V.

29/ This is based on data appearing in The Postcensal Study of Professional and Technical Manpower, and Formal Occupational Training of Adult Workers--Extent, Nature, and Use, U.S. Department of Labor, Office of Manpower, Automation and Training, 1964.

30/ Technician Manpower in New York State, op. cit., Vol. I, p. 47.

company training than through any other means, the relatively large number of young technicians who have recently entered technician work with some college training indicates that this latter source is growing in importance. 31/ Furthermore, many employees now express a preference for technicians who complete post-secondary school training programs specifically designed to prepare students for technician jobs. 32/ The number of these programs is increasing rapidly. Therefore, it appears likely that technicians trained in junior colleges and other types of schools offering post-secondary preemployment technician training will constitute an increasing proportion of all new technicians during the years ahead.

Training for most technicians is a never-ending process, particularly as the work becomes more complex as a result of continuing technological advances. Thus, supplementary training often is taken by employed technicians. 33/ Such training may consist of evening courses in a college or university, correspondence courses, or company training, both in the classroom and on the job. Although many technicians take supplementary training to qualify for higher level jobs, many others take such training merely to keep abreast of new development, or to improve skills required in their present job.

*Methods of Training for Technician Jobs*. There are several basic methods of obtaining the training needed to enter a technician job. One method is training taken expressly to prepare for entrance into a technician job, which, for the purpose of this study, is called preemployment occupational training. This type of training is offered mainly in occupational curriculums in secondary and post-secondary schools, industry training programs, and in government sponsored training programs for unemployed workers (MDTA). Training or experience received during the course of education or training for other types of work is another basic method of preparing for a technician job. Such training is received in 4-year college and university bachelor's degree programs and during the training for and experience in Armed Forces technical work. Still another method of qualifying for technician work is by acquiring work experiece in a technician-related skilled or other job, often combined with correspondence or other academic training. The term, upgrading, is used throughout this report

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31/ See chapter II for a discussion of the educational attainment of technicians, by age.

32/ In a recent study conducted by the Manufacturing Chemists' Association, two-thirds of the employers contacted either prefer or require chemical technicians to have at least 1 or 2 years of college. Four out of five respondents prefer a formal 2-year college level course designed for chemical technicians rather than company training. Information buttressing this data were obtained by Bureau of Labor Statistics' representatives in interviews with officials of companies employing large numbers of technicians, which were conducted during the course of the preparation of this report.

33/ Harold F. Clark and Harold S. Sloan, *Classrooms in the Factories* (New York, New York University Press, 1958); Oscar H. Serbein, *Educational Activities of Business*, (Washington, D.C. American Council on Education, 1961); and *Education for a Changing World of Work*, op. cit.

to describe the method by which workers acquire their technician training while employed in a technician-related job. The following sections describe these different types of training in detail.

(1) Preemployment training: (a) Secondary schools; (b) Post-secondary schools; (c) Industry; and (d) Government training programs.

(2) Technician-related training: (a) Colleges and university bachelor degree programs; and (b) Armed Forces.

(3) Work experience in technician-related work (upgrading).

## Preemployment Training

Secondary schools offering preemployment technician training include comprehensive high schools, vocational technical schools, technical high schools or vocational or trade schools. These schools usually provide background training for entrance into a post-secondary school. (For examples of curriculums and training programs mentioned in this chapter, see appendix C.)

In 1963, an estimated 13,000 students were receiving secondary school technician training in approximately 300 schools. 34/ Few advanced technical courses are offered in these schools, so graduates generally cannot enter technician jobs directly. However, follow-up studies indicate that about two-fifths of these graduates continue their education in post-secondary schools. Many receive additional training from other sources and eventually enter technician jobs. Therefore, secondary school preemployment technician training plays a much more important role in the overall picture of technician education than is indicated by the number of graduates going directly into technician occupations. 35/

Post-secondary preemployment technician training is offered primarily by technical institutes, junior colleges (also known as community colleges), area vocational-technical schools, and extension divisions of engineering colleges. The curriculums in technical institutes and extention divisions

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34/ This estimate is based upon statistics in Progress in Technical Vocational Education Programs Under Title III of the George-Barden Act, Fiscal Years 1959-1964 (Division of Vocational and Technical Education, Bureau of Educational Assistance Programs, U.S. Office of Education).

35/ In chapter V, which discusses projections of the supply of new technicians over the 1963-75 period, the number projected to enter directly from secondard school training is considered to be small. In some localities there are some secondary schools that offer training of a high caliber, and a large proportion of their graduates can qualify for entry into technician jobs. However, these graduates are also likely to continue their education full time in a college or university so that the number entering technician work from these schools is still believed to be small.

of engineering colleges generally are limited to programs designed to prepare graduates for a specific technician job or cluster of jobs immediately upon graduation. Junior and community colleges offer training for technicians and other occupations. Area vocational-technical schools provide some programs for technician occupation. 36/

Post-secondary schools offer 1, 2, or 3 years of full time technical training (or the equivalent in evening courses) beyond the high school level, usually two years. The typical curriculum includes basic science, general education, and technical courses such as drafting and strength of materials and use of instruments. Some training in the use of machines and tools is designed to familiarize the student with the equipment rather than to develop manual skills.

Students usually are required to spend half of their time taking specialized courses in the technology of their choice, e.g., electronics, mechanics, or chemistry. The remaining time is divided nearly evenly among general mathematics and science, and general education and technical courses. Laboratory work is emphasized so that students may become familiar with the instruments, equipment, and techniques used in industry. In general, the student receives intensive applied technical training but less theoretical and general education than he would get in the first two years of a 4-year engineering or science curriculum. 37/

In 1963, about 450 schools offered post-secondary technician training; about 100,000 full time students were enrolled. More than three-quarters of these students came directly from high school or the Armed Forces. 38/ Most of the remaining students had worked in a skilled or semiskilled job; others had dropped out of a 4-year college or university.

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36/ Because of the variety of types of schools offering preemployment programs, the curriculums vary considerably in content and quality. The Engineers' Council for Professional Development (ECPD) has established a procedure for accrediting programs in engineering technoloby. In 1965 approximately 100 programs in over 30 schools were accredited. It is not necessarily implied, however, that non-accredited programs do not meet the quality standards established by the ECPD. Some schools may not wish to have their programs accredited and for various technical reasons, others do not meet the accrediting qualifications. For information on accreditation procedures, see Engineers' Council for Professional Development, 32nd Annual Report for the Year Ending September 30, 1964.

37/ Occupational Criteria and Preparatory Curriculum Patterns in Technical Educational Programs, (U.S. Office of Education), OE 80015.

38/ This estimate is based on data appearing in G. Ross Henninger, op. cit.

About 25,000 students graduated from post-secondary preemployment technician training programs in 1963. 39/ Follow-up studies indicate that about 16,000 of these graduates entered technician jobs. 40/ The largest proportion of the remainder continued their schooling in bachelor's degree programs.

Industry technician training programs usually are intiated by employers when sufficient trained workers are not available. For example, junior and community colleges generally furnish training to meet existing demand in nearby localities for relatively large numbers of workers. Employers sometimes have a need for specialized skills that can be met only through their own training program.

Trainees may be in a skilled or other non-technician job, or may be high school graduates. Generally, to qualify for industry training, employed workers must have demonstrated superior ability in their present job and must show the desire and ability to perform technician work. New high school graduates usually must have had some mathematics and science training in high school; and for draftsmen jobs, they often need to have had some high school drafting training.

Industry technician training programs are usually organized programs in which academic training is integrated with extensive on-the-job training. The academic training is generally of three types: course work arranged by the employer in nearby educational institutions or in correspondence schools; employer plans which refund the tuition for academic work successfully completed; or classroom instruction provided during working hours in the plant by specialized training personnel employed by the company. Usually the on-the-job segment of the training program is integrated with the regular operation of the company. A few of the programs are registered with the Bureau of Apprenticeship and Training, most of which are aimed at training draftsmen and last from 3 to 5 years.

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39/ Estimates of the number of graduating post-secondary preemployment curriculums were based on data in Guide to Organized Occupational Curriculums in Higher Education (U.S. Office of Education), OE 56012-62, and Progress in Title VIII Programs, National Defense Education Act-1958, Fiscal Year 1963 (Technical Education Board, Division of Vocational and Technical Education, Bureau of Educational Assistance Program, U.S. Office of Education, July 1964).

40/ In addition to graduates of these programs, many dropouts enter technician jobs. However, these dropouts generally need some additional training to qualify for a technician job and are included as entrants in the type of training taken immediately prior to entering a technician job.

Industry technician training programs prepared an estimated 21,600 workers for entrance to technician occupations in 1963. 41/ An even larger number of employed technicians were able to keep abreast of new developments in their specialties or acquire new skills through industry training. 42/

The Manpower Development and Training Act of 1962, as amended (MDTA) provides training for technician and other occupations in which current shortages exist in a particular locality. MDTA technician training generally lasts about a year. (1965 amendment to the MDTA permitted the maximum length training to be extended from 1 to 2 years.) Training, both on the job and in classrooms, stresses applied technical courses, and offers little theory or general education courses. As a result, graduates of these programs are well grounded in the practical aspects of the particular occupations but tend to be less flexible than graduates of programs offering more instruction in theory.

Over 3,000 people were authorized to be trained for technician occupations under the MDTA during 1964--about half for various draftsmen occupations. Among the reasons for the large proportion of MDTA technician trainees enrolled in drafting programs is the fact that relatively little theory generally is required of draftsmen and these workers may be trained without the use of expensive equipment.

Technician-Related Training

Colleges and universities play an important role in preparing people to enter technician occupations. Because much of the work done by technicians overlaps the work done by scientists and engineers, the training given in science and engineering curriculums often qualifies students for some technician jobs. The training given in colleges in the first part of an engineering and science curriculum is in some ways similar to the training offered in a post-secondary preemployment technician training program.

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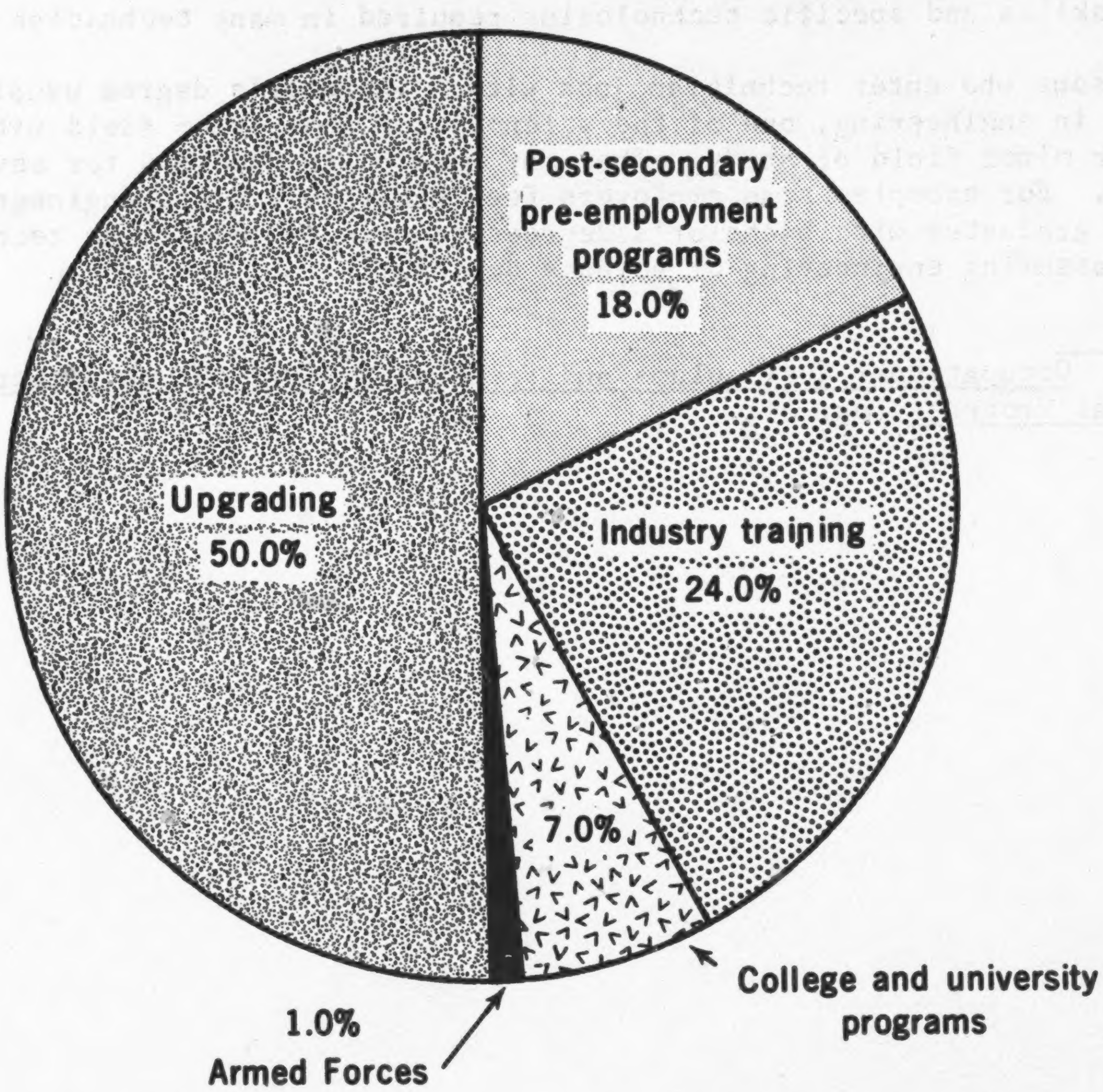
41/ This estimate is based upon several surveys which contain data on employer training (see chapter V for more detail on these surveys).

42/ This estimate primarily is based on data appearing in Training of Workers in American Industry (U.S. Department of Labor, Bureau of Apprenticeship and Training) Research Division Report No. 1, 1964.

## Chart 2. SOURCE OF TRAINING OF NEW TECHNICIANS 1/, 1963

Total entrants = 90,000



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1/ Only small numbers entered from MDTA programs prior to 1964.

The U.S. Office of Education has made a comparison of the first two years of a mechanical engineering curriculum with a two year technical institute curriculum in mechanical technology. 43/ In the mechanical engineering program, two-thirds of all courses during the first 2 years were in basic mathematics and science, as compared with only one-quarter of the courses in the mechanical technology curriculum. In the mechanical technology curriculum nearly one-half of the courses were in technology, as compared with less than 10 percent of the courses in the mechanical engineering curriculum. Consequently, technicians trained in college engineering or science curriculums are likely to work in positions requiring a strong theoretical background than in jobs that are essentially production oriented.

Students completing at least two years of engineering or science training usually have enough preparation in the basic sciences and mathematics for entrance into some technician jobs. However, they lack instruction in manipulative skills and specific technologies required in many technician positions.

Persons who enter technician jobs with a bachelor's degree usually have majored in engineering, one of the sciences, or some other field with science as their minor field of study. They may work as technicians for several reasons. For example, some employers feel that newly hired engineering or science graduates with bachelor's degrees require experience as technicians before assuming engineering or science duties.

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43/ Occupational Curriculums and Preparatory Curriculums Patterns in Technical Programs, op. cit.

An estimated 6,000 persons with two or more years of college training in an engineering or science curriculum entered technician occupations in 1963. Of this number, about half entered technician occupations after receiving the bachelor's degree.

Armed Forces technician training generally is oriented toward preparation for a particular job. The typical training includes instruction in the methods of operating, maintaining, and repairing specific types of military equipment, usually electrical or electronic equipment.

Armed Forces technician training is given in special training centers and in schools located throughout the country. Each branch of the service conducts its training separately. In the classroom and in the laboratory the trainee learns to use the equipment associated with his job. After completing classroom training, the trainee works on the job under the supervision of an experienced worker.

Technician training programs given in the Armed Forces generally last from 3 to 18 months. The training usually includes little theory and differs from that offered in civilian technician training programs only in that a minimum amount of time is spent on general principles and general education. Also, military electrical and electronic equipment usually is unlike equipment used in civilian industry. The vast majority of military technicians, therefore, must undergo additional training before they can enter civilian technician jobs.

Although the number of technicians separated from the Armed Forces in any given year is large, the proportion of these who enter civilian technician jobs directly after separation is believed to be small. In 1963, for example, only a small number of the estimated 34,000 persons separated from Armed Forces technician jobs are believed to have entered civilian technical work, but many do eventually enter civilian technician jobs after receiving additional training or experience. 44/

Upgrading should not be confused with industry technician training as described previously in this chapter. Upgrading usually is conducted by employers when they cannot recruit workers with preemployment or technician-related

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44/ Based on information in the Postcensal Study, op. cit.

training and when it is not economically feasible to initiate their own training program. 45/ Some employers, however, prefer to upgrade some workers to technician jobs as part of their overall promotional structure. 46/

Workers who are upgraded usually have had several years experience working in positions where they gain at least some familiarity with the technician job that they will fill. In general, they must show exceptional ability and evidence a desire for advancement by taking advanced mathematics and science courses in night school or through correspondence programs. However, a background that includes some technician training in secondary schools, the Armed Forces, or part of a post-secondary preemployment curriculum often is viewed by employers as indicating a worker's capability for upgrading.

The number of workers upgraded in any one year is believed to be heavily dependent on the relationship between the employer's need for technicians and the number available from other sources of supply, and thus tends to be extremely flexible. In the past, upgrading has been one of the major sources of technician supply. In 1963, an estimated 45,000 workers entered technician jobs in this manner, making it the largest single source of technician supply. 47/

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45/ Response from company officials in interviews conducted in connection with the preparation of this report indicate that the costs of initiating a training program could be more costly in the long run than having a relatively unproductive worker on the job until such time as he gains the training to perform his work adequately through his job experience. This is especially true in small establishments.

46/ In such cases, employers usually provide some short term training and there may be a very fine dividing line between these upgraded workers and others completing industry training programs.

47/ The projections of supply of technicians presented later in the report show that, in the future, upgrading will continue to be a major part of the supply although its importance will decrease significantly.

# Chapter IV. Requirements for Technicians, 1963-1975

Projections of the Nation's requirements for technicians between 1963 and 1975 rest heavily on several general assumptions, including those concerning defense spending and the level of unemployment in the Nation as a whole. Making judgments about future events which will influence these factors is, of course, difficult. Furthermore, basic data on technician manpower are weak, and often limited to only a few years of historical trends, and for many of the factors that should be taken into account in making the projections, there are no reliable data. Nevertheless, the projections of technician requirements presented in this chapter are believed to be valuable in assessing the need for technician manpower and the adequacy of technician supply from the various sources of training, and in helping to point the way toward improvement of the basic data.

The projections of technician needs include not only needs resulting from growth in requirements, but also those stemming from personnel losses due to deaths, retirements, and transfers of technicians to other fields of work. The projections were developed without explicitly considering the supply that might be available from the various sources. 48/ Similarly, they do not take into account the dynamics of manpower supply-demand situations, which may result in changes in demand or supply whenever a balance does not exist. For example, in a case where the demand for workers in an occupation exceeds supply for an appreciable period, there tend to be (1) changes in manpower utilizational patterns resulting in a reduction in the demand for workers in that occupation; and/or (2) an increase in the supply brought about by information on the improved employment opportunities or rising salary levels. Actual employment levels in 1975 thus will be the result of the interaction of supply and demand, moving generally toward the side of the supply-demand equation that can be most readily altered. As a result, the projections of requirements represent estimates of the Nation's needs for technicians in 1975 under a given set of assumptions, rather than predictions of actual employment levels which take into account the interactions of supply and demand.

The projections of technician requirements are meant to apply only to the overall long-run period ending with 1975. The reader is cautioned against interpolation between the 1963 and 1975 figures to derive estimates for any other year.

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48/ See chapter V.

## Methodology

*General Approach to Projecting Requirements.* In general, the methodology used to project requirements for technicians in 1975 is similar to the methodologies used in two previous BLS studies covering projections of scientists, engineers, and technicians. 49/ First, projections of employment requirements by industry were based on general assumptions concerning the nature and composition of the economy in 1975. 50/ Within this broad economic and manpower framework, the assumption was made that future technician requirements will continue to be related to the same economic parameters that they have been in the past, i.e., scientific and engineering manpower requirements, research and development activities, and others, to be described later. In order to better understand the effects of possible changes in technician requirements resulting from changes in these and other basic assumptions, projections were made using three different sets of assumptions.

In determining the parameters appropriate for analyzing technician requirements, three factors were considered: (1) the existence of a casual or logical relation between the parameter and requirements for technicians; (2) the availability of sufficient historical data for the parameter to permit an analysis of technician requirements and the parameter over time; and (3) the capability of projecting the parameter independently.

After examing a number of possibilities, three parameters appeared to be appropriate for analysis; (1) the relationship between requirements for technicians by field of specialization and the employment of engineers and scientists in similar fields of specialization; (2) the relationship

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49/ *The Long-Range Demand for Scientific and Technical Personnel--A Methodological Study*; op. cit., and *Scientists, Engineers, and Technicians in the 1960's--Requirements and Supply*, op. cit. Although the methodology used for projecting technician requirements in these two studies was basically similar to the methodology used in this report, the major objective of the earlier studies was to assess the future requirements and supply of scientific and engineering manpower, and consequently relatively little effort was devoted to analyzing future requirements for technicians. This report builds upon the base developed in the earlier studies and thus presents a more comprehensive analysis of technician requirements.

50/ These projections were made as part of the Bureau of Labor Statistics overall occupational outlook program and not specifically for this report. (See *America's Industrial Occupational Manpower Requirements 1964-1975* prepared by the Bureau of Labor Statistics for the National Commission on Technology, Automation, and Economic Progress).

between requirements for technicians and the employment of all professional, technical, and kindred workers (PTK) by industry; and (3) the relationship between requirements for technicians and total employment by industry.

The relationship between requirements for technicians by field of specialization and the employment of engineers and scientists in similar fields of specialization appeared to best meet the criteria and permit an analysis by the greatest industry and occupational detail, and thus was used as the primary method of making the projections. 51/

Projections also were made based on the other two parameters as a means of checking the primary projection even though it was apparent that a considerable degree of overlap existed among the three methods. These projections provided similar results and furnished some useful insights into the primary projection methodology.

### Primary Method of Projecting Requirements

Among the major assumptions underlying projections of the Nation's technician requirements are: An unemployment rate of 3 percent of the Nation's labor force in 1975 and a continuation of current high rates of economic growth; continued growth of research and development expenditures, although at a slower rate of growth than shown in the late 1950's and early 1960's; high levels of defense and space spending not significantly different from those of the mid-1960's prior to the Viet Nam buildup; and continuation of current levels of technological innovation. These are the same assumptions that underly the projections of industry and occupational requirements making up the economic model used by the Bureau of Labor Statistics in a great part of its work. 52/

Implicit in the primary method of projecting requirements for technicians--i.e., the relationship between technician requirements and the requirements for scientists and engineers--is a continuation of the basic occupational structure of industry, in which technicians work as members of a team, closely supporting and directed by scientists and engineers. Also, the projections assume that the supply of scientists and engineers will roughly equal demand in 1975. If not, employers would probably change significantly their utilization patterns, and the employment relationship of technicians to scientists would be severely affected.

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51/ Interviews with employers reinforced the conclusion that needs for technicians to a large degree are determined by employment of scientists and engineers. This was substantiated by the results of several surveys and by an examination of pertinent literature. For example, see Arizona's Manpower Challenge of the 1960's (Arizona State Employment Service, Phoenix, 1960), G. Ross Henninger, op. cit., and Education for a Changing World of Work, op. cit.

52/ For a more detailed discussion of the economic model underlying the projections, see America's Industrial and Occupational Manpower Requirements 1964-1975, op. cit.

Projections of the requirements for scientists and engineers in 1975, by specialty and industry were made utilizing the previously discussed general assumptions. 53/ The methodology used to make these projections was essentially the same as that outlined in Scientists, Engineers, and Technicians in the 1960's--Requirements and Supply. 54/ The major steps were as follows: (a) Ratios of scientists and engineers to total employment were established for detailed industries in each sector of the civilian economy--including private industry, government, and colleges and universities--for the base year 1963 and for all previous years for which data were available. (b) Ratios in each industry were projected to 1975 on the basis of the factors affecting employment in each industry and taking into account past and anticipated trends. (c) The projected ratios of scientists and engineers for each industry were then applied to independent 1975 projections of total employment requirements, by industry, to yield first approximations of scientific and engineering manpower requirements in 1975. (d) The first approximations of 1975 scientists and engineering manpower requirements in "c" were then examined in detail, analyzed for reasonableness, and adjusted where necessary.

The next step in the projection methodology was the development of ratios of technician employment to the employment of scientists and engineers in a related occupational specialty for 1963, and as many earlier years as possible. Ratios were developed separately for each major employer and for eight technician occupational groups. Employment of draftsmen and engineering technicians were related to the employment of engineers; life science technicians were related to life scientists; mathematics technicians to mathematicians and mathematical statisticians; chemical technicians to chemists; physics technicians to physicists; "other" physical science technicians to "other" physical scientists; and all other technicians to total scientists and engineers. 55/

Ratios for these groupings were developed separately for each major industry, because of industry differences in technological and institutional characteristics, such as the amount of research and development activities, and

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53/ These projections were made in conjunction with the occupational outlook program of the Bureau and were not made specifically for this study. An article discussing the projected 1975 requirements for scientists and engineers by occupation and industry will appear in a late 1966 issue of the Monthly Labor Review.

54/ Op. cit., pp. 5-17

55/ The "all other" group of technicians is an extremely heterogenous one and, therefore, cannot be logically related to any specific science or engineering occupation.

in the patterns of technical manpower utilization. 56/ The ratios of technicians to scientists and engineers, by occupational specialty and industry, were then projected to 1975, based on judgments as to the factors expected to influence the ratios in the future, and taking into account past trends in the ratios.

Data on past trends are available primarily from the previously discussed BLS surveys of scientific and technical personnel in industry. 57/ These surveys show that the ratio of technicians to scientists and engineers has changed only slightly in recent years rising an average of about 1 percent annually from 1961 to 1963.

A similar change also is shown by 1950 and 1960 census data, which indicate that the ratio of draftsmen to engineers increased by 13.6 percent over the 10-year period. 58/ Other limited data on past trends indicate that the ratio of technicians to scientists and engineers has increased relatively slightly in recent years. 59/

A similar future increase in the ratio of technicians to scientists and engineers was shown by a survey conducted by the Engineering Manpower Commission (EMC) in late 1963, 60/ in which employers were asked to estimate the number of engineers and technicians they expected to employ in 1973, as well as to provide data on actual employment in 1963. An analysis of the report shows that the ratio of technicians to engineers in private industry was expected to increase by about 8 percent over the 10-year period.

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56/ The ratio of technicians to scientists and engineers also differs among functions, as was illustrated clearly by a recent study of the aerospace industry conducted by the Stanford Research Institute, The Industry-Government Aerospace Relationship, Volume II--Supporting Research, prepared for Aerospace Industries Association of America, Inc., Stanford Research Institute, Menlo Park, Calif., 1963. In that industry, the study pointed out, the median number of technicians per 100 engineers and scientists was 43 in all functions, but 14 in production, 19 in research, 32 in development, 322 in testing, and 5 in other functions. However, detailed information on the functions of technicians in other industries was not available with which to add this further refinement.

57/ Scientific and Technical Personnel in Industry--1959, NSF 60-62, 1960; Scientific and Technical Personnel in Industry--1960; NSF 61-75, 1961; Scientific and Technical Personnel in Industry--1961, NSF 60-62 (All published by the National Science Foundation); Employment of Scientific and Technical Personnel in Industry--1962 (BLS Bulletin 1418, 1964); 1963 data is based on unpublished preliminary data.

58/ The comparison was used between draftsmen and engineers because these are the only two occupations which are easily identifiable in both 1950 and 1960 censuses.

59/ Among these sources are the surveys of State Government employment of technicians by the BLS, and Federal white-collar and blue collar employment data collected by the U.S. Civil Service Commission.

60/ Demand for Engineers, Physical Scientists, and Technicians--1964, July, 1964.

A more general analysis of the factors that may influence the relationship of technicians to engineers and scientists also indicates a long-term increase in the ratio. Among these factors are (1) an increasing awareness of employers that they can better utilize scientists and engineers by providing them with more support personnel; and (2) rising salaries for scientists and engineers which have and are expected to continue to result in increased utilization of technicians.

Based on changes in the ratio of technicians to scientists and engineers indicated by the previous analyses, an increase of about 10 percent in the ratio of engineering and physical science technicians, life science technicians, and "other" technicians to scientists and engineers was projected from 1963 to 1975. The ratio of draftsmen to engineers was projected to remain roughly the same in 1975 as in 1963. Technological developments in the drafting field, such as photo-reproduction of drawings and electronic drafting equipment, are expected to increase the amount of work that can be performed by draftsmen and limit any increase in the ratio.

These assumed ratios could be sharply affected by severe changes in the supply-demand relationship for scientists and engineers. However, data on the possible situations are not readily available, and the art of making projections is not yet sophisticated enough to permit a consideration of all factors in making quantitative projections of technician requirements. 61/

The moderate increase in the ratio of technicians to scientists and engineers is projected in the face of several surveys which show that, ideally, employers would like to increase the ratio of technicians even more. In a survey conducted by the American Society for Engineering Education, for example, the 50 companies surveyed indicated that they would prefer the ratio of engineering technicians to engineers to be 1:1, instead of .8:1 as it was at the time of the survey (1957). Furthermore, these companies indicated that they would like to see the ratio increase to 1.9:1 in 1967. The results of several other studies are roughly similar. 62/ In order to provide information on the effects of a substantial increase in the ratio of technicians to scientists and engineers, projections under alternative assumptions are presented later in this chapter.

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61/ The qualitative effects of these factors are discussed further in the section concerning alternative assumptions.

62/ In Education for a Changing World of Work, op. cit., it is anticipated that "the indicated needs call for a ratio of at least 2 to 1 between technicians and engineers." Also, a survey of employers conducted by the Manufacturing Chemists' Association indicate large increases in the ratios of technicians to scientists and engineers as desirable.

After projected ratios of technicians to engineers and scientists by occupational specialty and industry were developed, they were applied to the appropriate projections of scientific and engineering manpower requirements in each industry to yield projections of technician manpower requirements in 1975. A discussion of the resulting projections, termed the "intermediate" projections, appears later in this chapter. (See pp. 80-82 and appendix table A-3.)

Secondary Methods of Projecting Requirements

Projections of technician requirements also were developed using two different methods than that just described. This was done in order to check the projections prepared under the primary method, and to assure reasonableness and consistency with other economic factors.

One secondary method involved the establishment of ratios for 1963 employment of technicians, by broad occupational specialty, to the employment of professional, technical, and kindred workers (PTK) by industry. 63/ Trends in the ratio of technicians to PTK during the 1950's and early 1960's were analyzed in detail and projected to 1975. The ratios of technicians to PTK workers, by industry, were then applied to the industry distribution of projected employment of PTK workers--about 13.2 million in 1975. 64/

The other secondary method used to project technician requirements was based on the relation of technician requirements to total employment in each economic sector. 65/ The first step in this methodology was development of ratios of 1963 employment of technicians, by occupational specialty, to 1963 employment of all workers, by industry. These ratios were then projected to 1975, based on an analysis of past trends and factors expected to alter future relationships of technicians to total employment. The projected ratios, by industry, were applied to independent projections of each industry's anticipated requirements in 1975, utilizing the independent projections from the BLS economic model. 66/

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63/ Information on employment of PTK workers by industry are unpublished BLS data.

64/ Unpublished data prepared by the Bureau of Labor Statistics.

65/ Evidence of a fairly high correlation between total employment and employment of technical workers in a given industry has been provided by other studies. For a discussion see the Long-Range Demand for Scientific and Technical Personnel, op. cit., pp. 1-6.

66/ These industry projections were also used to develop requirement projections for scientists and engineers in the primary methodology.

The projections of technician requirements prepared using the two secondary methods yielded results that were relatively similar to the results achieved through the primary methodology. The final projection, although derived basically by the primary methodology, was compared and examined in detail for reasonableness and consistency with those developed by the secondary methods.

Alternative Projections

Because manpower projections are influenced significantly by the assumptions used, the primary methodology was used to develop two sets of alternative projections of technician requirements based on different assumptions. These alternate projections are provided in order for the reader to understand the impact of the assumptions used, and to permit him to use different assumptions if so desired. However, it is not possible with the limited data available to develop a model showing the entire range of possible requirement projections. As indicated, the alternative projections utilize the primary method of projecting requirements.

High Demand. The first alternative projection reflects a higher level of demand for technicians than the "intermediate" projection described earlier in this chapter. The major change from the assumptions set forth in the "intermediate" projection was the use of a much higher than 10 percent rise in the ratio of technicians to engineers and scientists (by specialty) between 1963 and 1975. 67/ This assumption of a sharper increase in the ratio is based on surveys discussed previously where employers indicated a desire that the ratio increase greatly. However, many surveys show an unreasonably high desired ratio in 1975, too far removed from current utilization patterns to be completely acceptable; for the purpose of this study's first alternative projection, an increase in the ratio of one-third was assumed to occur over the 1963-75 period. 68/ These adjusted ratios were then applied to the same projections of requirements for engineers and scientists by occupational specialty and industry described earlier.

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67/ In the "intermediate" projections the ratio of draftsmen to engineers was assumed to remain the same in 1975 as in 1963. The projections of scientists and engineer requirements used here were identical to those used in the primary projection of technician requirements.

68/ As stated previously, any increase in the ratio of draftsmen to engineers is likely to be lower than that of engineering and science technicians to scientists and engineers. Thus, in the illustration of high demand, the ratio of draftsmen to engineers was increased by 10 percent rather than the one-third increase used for the other technician occupations.

Among the factors that might result in such an increase in the ratio would be a large increase in research and development and other activities requiring large numbers of technical personnel but without an equivalent increase in the supply of scientists and engineers to meet the demand. Under such conditions it is assumed that employers would increase their technician to engineer and scientist ratio. Another condition which might result in such a significant increase in the ratio would be a continued rise in salaries of scientists and engineers, providing salaries of technicians did not rise as much relatively. Under this situation employers might hire more technicians relative to scientists and engineers. Similarly, increased awareness of the value of technical assistance for scientists and engineers might also bring about such a rise.

Low Demand. The second alternative projection, which resulted in a projection of "low demand" for technicians assumes, in 1975, a level of scientific and engineering manpower requirements below that used in the intermediate projections and a concomitant decrease in technician requirements. Factors which might bring about lessened requirements for scientists and engineers include a significantly lower level of defense and space activities in 1975 than in 1963; a slower increase in research and development expenditures than postulated in the intermediate projection; and a general slowdown in economic activities. Similarly, the net affect on technician requirements would be the same if the demand for scientists and engineers remained the same as in the intermediate projection, but the ratio of technicians to scientists and engineers declined.

The limited data available and the art of making projections do not allow for the consideration of all the many quantitative relationships and assumptions that can be established in one projection model. For example, if 2 or 3 assumptions were made for each of the several inputs to the projections, a geometrical miltiplication would result in an unmanageable number of projections. Nevertheless, the numerical estimates of technician requirements in 1975 presented in this report, along with the qualitative information on factors affecting technician requirements presented throughout the chapter, are believed to be valuable in assessing the needs of the economy for technician manpower and evaluating the educational programs designed to train these workers.

Replacement Needs

In addition to technicians needed to meet growth in requirements from 1963 to 1965, others are needed annually to replace those employed in 1963 who will retire, die, or transfer to other occupations by 1975. [69]

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[69] Losses for new entrants during the 1963-75 period who leave the profession by 1975 are accounted for in the supply figures presented later.

Losses resulting from deaths and retirements were estimated by applying separation rates, developed from the 1960 tables of working life for men, 70/ to estimates of the number of technicians in different age groups in 1963. The tables of working life for men were used because of the relatively small number of women employed in this field. 71/ The resulting estimates indicate that an average of about 1.2 percent of the technicians employed in 1963 will leave the field each year between 1963 and 1975 because of deaths and retirements.

Other personnel losses which were taken into consideration in estimating replacement needs include transfers of technicians to other occupations, which represents a much larger number than those dying or retiring. For example, some qualified technicians are upgraded each year to engineering jobs. Despite their importance, little data are available upon which to base a numerical estimate of these losses. However, the Postcensal Study of Professional and Technical Manpower has recently provided data which gives some limited information on occupational mobility of technicians. 72/ Based on an analysis of the Postcensal Study and other limited data, it is estimated that about 3 percent of the technicians employed in 1960 left the field each year between 1960 and 1962. 73/ Since little is known about the circumstances underlying this occupational mobility, in order to estimate transfer losses between 1963 and 1975, it was assumed that the transfer rate would remain at the 1960-62 level.

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70/ The Length of Working Life for Males, 1900-63, (Office of Manpower, Automation, and Training, U.S. Department of Labor, 1963) Manpower Report No. 8.

71/ See chapter II, table 6.

72/ Op. cit.

73/ This estimate of occupational mobility of technicians is considerably higher than estimates previously used. In Scientists, Engineers, and Technicians in the 1960's--Requirements and Supply, op. cit., the occupational mobility rate used for technicians was .75 percent a year.

## Highlights of the Projections

This section presents the highlights of the "intermediate" projections of technician requirements in 1975, 74/ and estimates of the number of technicians needed to replace those who will die, retire, or transfer to other occupations during the 1963-75 period. Following the summary of the "intermediate" projections, the needs for technicians developed under the "high" and "low" demand assumptions are presented.

Summary of Intermediate Projections. The intermediate projections developed for this report indicate that requirements for technicians may increase by about 650,000 over the 1963-75 period, rising from the 845,000 employed in 1963 to about 1,495,000 needed in 1975. This projected growth represents about a 77 percent increase over the 12-year period, an average rate of increase of about 6.4 percent a year, a rate of growth similar to that which has occurred in recent past. 75/ Increased requirements for technicians are expected to result from continued economic growth, especially in the technical fields where growing complexities of new products and processes will stimulate demand for highly trained technical personnel. Growth will also stem from factors such as increasing utilization of technicians, expanding research and development activities and exploitation of the resulting discoveries especially in the field of medical science, and further slight expansion of the space program.

The most rapid increase in requirements is expected to be for life science technicians. (See table 7.) Demand for these workers is projected to increase from the less than 60,000 in 1963 to 139,000 needed for 1975, a 139 percent increase over the 1963-75 period. Requirements for engineering technicians, the largest technician specialty, are expected to grow from about 309,000 in 1963 to 533,000 in 1975, or by about 73 percent, a rate of increase similar to the rate for all technicians. Because of the relative size of the field, however, more people will be needed to fill openings arising from growing requirements in the engineering technician specialty than in any other specialty. Requirements for draftsmen are expected to increase by 62 percent, the smallest projected increase of all technician specialties.

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74/ The "intermediate" projections refer to estimates developed under assumptions which at the time the report was prepared in late 1965 were judged most likely to occur in 1975. They are indicated as "intermediate" because they lie between the estimates developed under alternative assumptions illustrating "low" and "high" demand conditions.

75/ This estimate is based on data on private industry employment from Employment of Scientific and Technical Personnel in Industry, reports for 1960, 1961, 1962, and 1963, which represents about three-fourths of all technician employment.

Table 7. Technicians, by Occupational Specialty, 1963 Employment and Projected 1975 Requirements

| Occupation | 1963 employment | Projected 1975 requirements | Percent increase, 1963-75 |
|---|---|---|---|
| Technicians, all occupations-- | 844,800 | 1,495,000 | 77 |
| Draftsmen---------------------- | 232,000 | 375,000 | 62 |
| Engineering and physical science technicians------------- | 439,000 | 765,000 | 74 |
| Engineering technicians-------- | 308,500 | 533,000 | 73 |
| Chemical technicians----------- | 64,600 | 122,000 | 89 |
| Physics technicians------------ | 10,800 | 22,000 | 104 |
| Mathematics technicians-------- | 6,100 | 12,000 | 97 |
| Other physical science technicians------------------ | 49,000 | 81,000 | 65 |
| Life science technicians--------- | 58,100 | 139,000 | 139 |
| Other technicians---------------- | 115,700 | 210,000 | 82 |

Note: Because of rounding the sum of individual items may not add to totals.

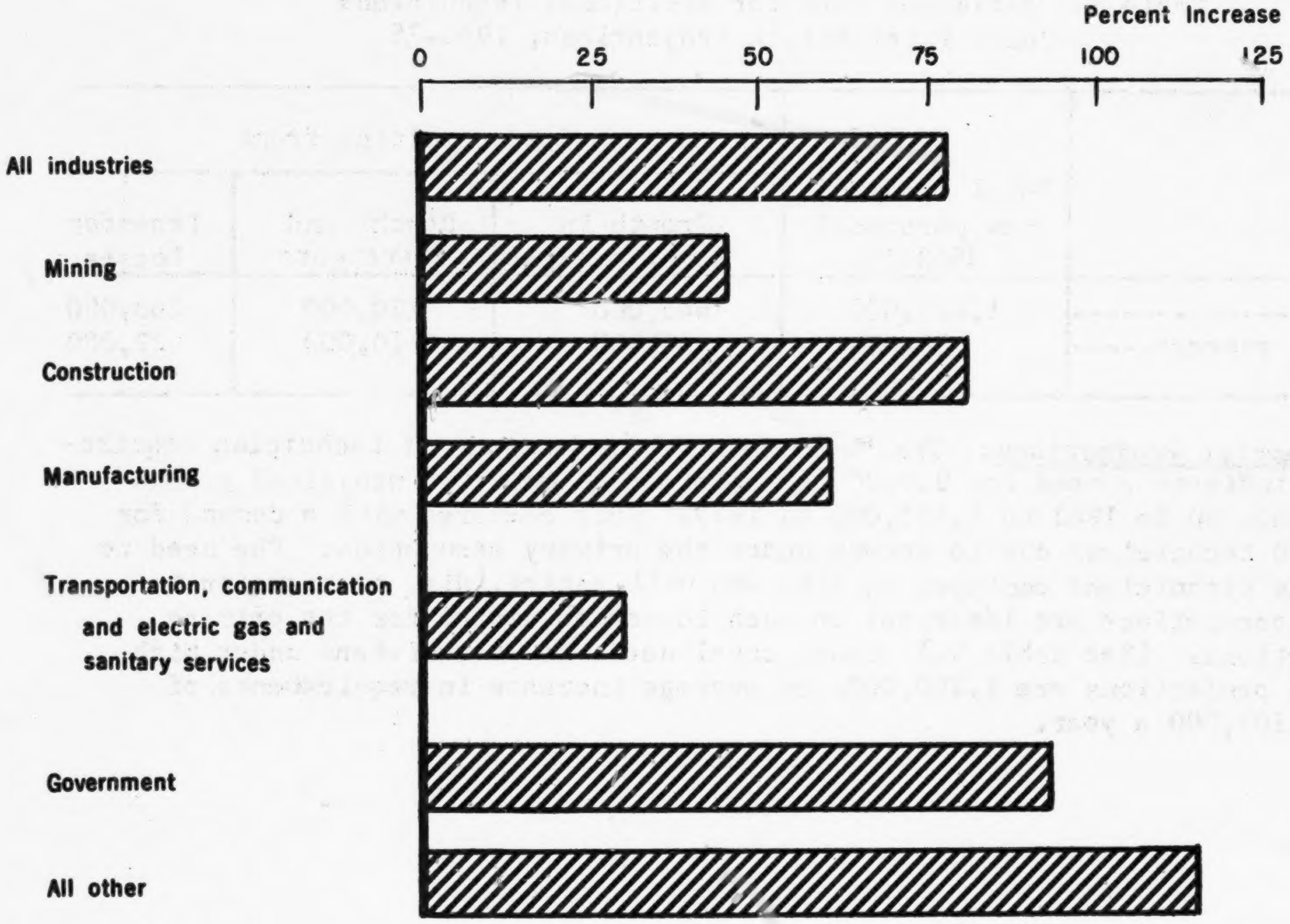
**The projections indicate that, between 1963 and 1975, requirements for technicians in several bread industry divisions will increase more rapidly than the 77 percent anticipated for the economy as a whole. (See chart 3.) These are Government, construction, and a miscellaneous group of industries that includes nonprofit organizations, engineering and architectural services, miscellaneous business services, and colleges and universities. (The growth in colleges and universities is expected to be almost exclusively in research centers.) In manufacturing, rapid growth of requirements are expected in the**

chemicals and allied products, rubber products, and professional and scientific instruments industries. (Projections of requirements for technicians in detailed manufacturing industries are shown in Appendix table A-3.)

Chart 3.

## ESTIMATED PERCENT INCREASE IN REQUIREMENTS FOR TECHNICIANS BY BROAD INDUSTRY GROUPS, 1963-75

(Intermediate projections)



Replacement Needs. Although technicians are a relatively young group of workers, losses to the occupation from retirements and deaths are expected to average nearly 10,000 a year during the 1963-75 period, nearly 120,000 over the 12-year period. Losses owing to transfers would average about 22,000 a year over the 1963-75 period, or nearly 260,000 for the period as a whole. Use of a different transfer rate would alter significantly the number of technicians needed as replacements. For example, if transfers to other occupations were to decline from 3 to 2 percent, transfer losses would decrease from 260,000 to about 175,000 over the period.

## Summary of Demand for Technicians, 1963-75

To meet the new personnel needs resulting from growth in requirements (under the intermediate projection) and from losses due to deaths, retirements, and transfers, about 1,025,000 additional technicians would be needed during the 1963-75 period. (See table 8.) Of these, about 645,000 technicians would be needed as a result of increased requirements due to growth of the field; 260,000 as a result of transfers of experienced technicians to other fields of work; and 120,000 as a result of deaths and retirements.

Table 8. Estimated Need for Additional Technicians
Under Intermediate Projections, 1963-75

| | Total need for new personnel 1963-75 | Need resulting from: | | |
|---|---|---|---|---|
| | | Growth in requirements | Deaths and retirements | Transfer losses |
| Total | 1,025,000 | 645,000 | 120,000 | 260,000 |
| Annual average | 86,000 | 54,000 | 10,000 | 22,000 |

Alternative Projections. The "high demand" projections of technician requirements indicate a need for 910,000 technicians to meet the projected growth from 845,000 in 1963 to 1,755,000 in 1975. This compares with a demand for 645,000 technicians due to growth under the primary assumption. The need to replace technicians employed in 1963 who will retire, die, or transfer to other occupations are identical to such losses developed for the primary projections. (See table 9.) Thus, total needs for technicians under high demand projections are 1,290,000--an average increase in requirements of about 107,000 a year.

Under the "low demand" assumption, the projections indicate a growth from 845,000 technicians employed in 1963 to 1,352,000 in 1975. This represents an increase in requirements of 507,000, as compared with an increase of about 645,000 under the primary assumptions. Total needs for technicians under the "low demand" projection of technician requirements in 1975 would be 887,000--an average increase of about 73,900 a year.

Table 9. Estimated Need for Additional Technicians, 1963-75,
Under "Low," "Intermediate," and "High" Projections

| Level of Demand | Total need for new technicians, 1963-75 | Average annual increase |
|---|---|---|
| Low demand---------------------------------- | 887,000 | 73,900 |
| Intermediate demand----------------------- | 1,025,000 | 86,000 |
| High demand--------------------------------- | 1,290,000 | 107,500 |

## Chapter V. Supply of Technicians, 1963-75

Under the intermediate projections, the Nation may require about 1,025,000 new technicians between 1963 and 1975. Projections of the number of technicians expected to enter the field from preemployment and technician-related training are derived independently of the requirement projections. 76/ Because employers generally use upgradings as a source of supply when the supply from other sources is not sufficient to meet demand, 77/ the projections of upgradings equals the projection of requirements minus the net supply from preemployment and technician-related training. This chapter discusses the independently derived projections of supply from preemployment and technician-related training. Upgradings are discussed in the following chapter which presents the implications of the supply and requirements projections.

In evaluating the projections of the supply of technicians presented in this report, it should be noted that at the time this report was prepared in late 1965, relatively little historical data were available on entrants from the various sources of supply. For example, past data on new entrants from MDTA programs were only available since 1962. Furthermore, the supply of technicians with post-secondary preemployment training was increasing at a rapid rate as a result of simulus from recent Federal legislation. Consequently, historical data were used primarily to aid in understanding relationships between casual factors influencing the supply of technicians, rather than as an input to the development of the actual projections. Therefore, many assumptions had to be made concerning the factors affecting future technician supply, and on the significance of their impact.

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76/ As described in chapter III, preemployment training includes secondary school programs, post-secondary occupational programs, MDTA training, and industry training; technician-related training includes that received in college and university bachelor's degree programs and in the Armed Forces.

77/ As illustrated previously, many employers prefer to obtain some of their new technicians as part of a policy of promotion from within. However, data are lacking as to the number upgraded for this reason and in this report, these are included in the upgraded category.

Data are limited on the proportion of new entrants from each type of training that enter the specific technician occupational groups. Therefore, in the supply projections developed for this study, only new entrants to the overall technician group are calculated and the supply for the major occupational groups within the total are not isolated. Clearly, such a delineation is a desirable goal for future researchers on technician manpower.

Several basic qualitative assumptions underlying the projections of new entrants into technician occupations are: (1) that employers will prefer to hire workers who have completed preemployment or technician related training, rather than upgrade workers from skilled positions; (2) that salary differentials between technician and other occupations will have no greater or lesser effect on attracting workers into technician jobs than in the recent past; and (3) that problems of occupational status will not limit the number of new technician entrants any more than in the recent past. 78/

Supply projections presented in this chapter are only illustrative estimates of what would happen under given assumptions. If actual future developments should differ significantly from the assumptions used in developing the projections, the supply estimates would change accordingly. To illustrate the effect of different assumptions, alternative projects are presented for each of the formal sources of supply.

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78/ It is evident that some difficulty exists in attracting people to technician occupations. However, in this report, no attempt has been made to take into account the psychological and sociological aspects of jobs which motivate an individual to enter technician training or to accept technician employment. Information on this subject is available in Technical Education in the Junior College/New Programs for New Jobs, Norman C. Harris, American Association of Junior Colleges, Washington, D.C., 1964 (page 81); The Emerging Role of the Engineering Technician, "Effective Utilization of Technician Manpower," University of Dayton, Dayton, Ohio, 1961; The Engineering Technician: Dilemmas of a Marginal Occupation, William M. Evans, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1963 (pages 11-14); Proceedings of Technical Manpower Utilization Conference, "Strengthening the Status of the Engineering Technician," Sponsored by the Missouri Society of Professional Engineers under the auspices of the Executive Office of the President of the United States, Kansas City, Missouri, 1962.

## General Methodology of Supply Projections from Preemployment and Technician-Related Training

**Projections of the supply of technicians from preemployment and technician-related training were made independently of the requirement projections presented in chapter IV. 79/ Estimates of the number of technicians who are expected to enter the field are presented for each year from 1963-74, 80/ for the following types of training: preemployment training in a post-secondary occupational curriculum, industry programs, and in MDTA programs; 81/ and technician-related training in a bachelor's degree curriculum in a college or university, and in the Armed Forces. Although many new entrants to technician occupations have more than one type of training, projections of the number who enter from each source represent those whose training immediately preceeds employment in a technician occupation.**

**One general approach was followed in developing the estimates from each type of training. First, the number of persons completing each type of training each year were estimated. Next, the proportion of persons who, having completed training, will actually enter technician occupations was estimated. In order to estimate the number of these new technicians who would still be working as technicians in the target year 1975, estimates were made of the number who would leave the occupation before that year because of transfers to other occupations, retirement, or death;**

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79/ Because upgrading is used most often by employers to fill technician jobs that cannot be filled in other ways, estimates of the number of workers upgraded into technician jobs were developed as a residual of the requirements for technicians after allowance for the number expected to be available from other sources. (See chapter VI.)

80/ Entrants in 1963 are included in the supply projections since these entrants are not counted in the 1963 employment estimates. Similarly, entrants in 1974 will be the last ones available from employment in early 1975.

81/ In chapter III, it was pointed out that some secondary schools offer preemployment training. However, it is believed that this training is neither intensive nor extensive enough to prepare a graduate to enter a technician job immediately upon graduation. Consequently, these graduates almost always must have advanced training from another source before they are eligible for technician jobs. Such entrants are included with those who are prepared for their job in other ways.

these were deducted from the number of new entrants. Finally, to determine the supply of technicians in 1975, excluding those who may have to be upgraded to meet the anticipated demand, the estimates of new entrants surviving in 1975 were aggregated with the estimated number of technicians employed in early 1963 who are expected to still be in the technician workforce in 1975.

### New Entrants From Preemployment Training Programs

The projections of new entrants from preemployment training include those from post-secondary occupational training programs, industry training programs, and MDTA programs. The number of new entrants directly from secondary school preemployment programs is believed to be small and separate projections of such entrants are not presented.

### New Entrants from Post-secondary Preemployment Occupational Curriculums

The projections of new entrants completing post-secondary preemployment technician training programs in technical institutes, junior colleges, and area vocational technical schools, and in extension divisions of engineering colleges were based on: (1) projections of enrollments in each type of program; (2) projections of the proportion enrolled who will graduate; and (3) estimates of the proportion of graduates who will enter technician occupations.

Among the general assumptions underlying the projection are that Federal funds allocated for training technicians will be used, that the availability of facilities will in itself generate an increase in the number of enrollments, and that problems of status or salary will not limit the number of graduates entering technician jobs. It is assumed also that a sufficient number of teachers will be available to conduct the training.

Enrollments. Enrollments in post-secondary preemployment technician training programs are projected to increase greatly during the 1963-75 period. One of the chief factors underlying the projected increase is the passage of recent Federal legislation making funds available for technician education, including the Higher Education Facilities Act of 1963, the Vocational Education Act of 1963, and the Higher Education Act of 1965. The passage of the Higher Education Facilities Act of 1963 provides public community colleges and public technical institutes with 22 percent of any appropriations made under the act. In addition, any funds authorized to construct academic facilities for higher education facilities other than public community or junior colleges which are not used, may be transferred to the fund for community or junior colleges. Furthermore, with passage of the Vocational Education Act of 1963, Federal funds authorized under Title VIII of the National Defense Education Act of 1963 were made permanently available to States under Title III of the George Barden Act, to assist them in maintaining, extending, and improving existing programs of vocational and technical education through the junior college level, and in developing new programs. Extensive funds also have been made available under the Higher Education Act of 1965 to provide financial assistance to needy youths. An indication of the future effect of recent Federal legislation on the supply of technicians is illustrated by an examination of the impact of the National Defense Education Act of 1958 (NDEA), which provided funds for technician education. Federal funds spent for technician training under Title VIII of the NDEA increased from $2.6 million in 1959 to $13.4 million in 1963, with most of the increase coming between 1960 and 1963. 82/ Mainly as a result of these increased funds, the number of graduates of preemployment post-secondary technician training programs increased from about 16,000 in 1960 to about 25,000 in 1963, following a period of stability between 1956 and 1960. 83/

Projected enrollments in post-secondary preemployment curriculums were developed on the basis of the assumed relationship of such enrollments to high school graduations. 84/ U.S. Office of Education projections indicate that the number of high school graduates will increase by about two-thirds between 1963 and 1973, 85/ rising from 1.95 million to 3.24 million. In the 1962-63 academic year, nearly 2 percent of the high school graduates of the previous 2 years were enrolled in post-secondary technician training programs. 86/ It was estimated that this proportion will continue to grow rapidly during the remainder of the 1960's, along with the anticipated growth in facilities resulting from recent legislation, and will level off during the first half of the 1970's, as the growth in facilities for training slows down. On this basis, the number of enrollments in post-secondary technician training programs would rise to about 257,000 in 1975--nearly three times the 1963 level. (See table 10.) Over the 1963-74 period, there is expected to be an average of about 186,000 persons enrolled each year in post-secondary preemployment technician programs.

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82/ Between fiscal years 1959 and 1964, total expenditures for technician training by all Government agencies were about 131 millions.

83/ These estimates are based on data in several Office of Education reports. See Organized Occupational Curriculums in High Education, Reports for 1956, 1958, and 1962, and Progress in Technical Vocational Education Projects under Title III of the George Barden Act, Fiscal Years 1959-1964.

84/ Although high school dropouts are eligible for post-secondary preemployment training in some schools, virtually all post-secondary trainees have graduated from high school.

85/ In order for a young person to be trained through a post-secondary preemployment training program and to be part of the available supply in 1975, he must finish high school by 1973 and be enrolled in a post-secondary program in 1974.

86/ Graduates of two high school classes are included in the analysis because enrollments in the first and second years of occupational curriculums are drawn basically from two consecutive high school classes.

Graduates. Since not all young people enrolled in post-secondary preemployment technician training programs graduate, the proportion of enrollees who are expected to graduate was estimated. 87/ Although the ratio of graduates to enrollments in well-established post-secondary technician training programswas estimated to be about one-third, in recently established post-secondary programs the ratio is much lower. 88/ Because of the large number of new programs recently initiated, the proportion of all enrolles graduating from post-secondary occupational programs in 1963 was estimated to be about 27.5 percent, roughly midway between the proportion for new and for well-established programs. The estimated proportion of graduates to enrollments in evidence in 1963 is expected to increase slowly, reaching about one-third in 1975, when the many new programs that will be set up over the 1963-75 period become well established. On this basis, and using the enrollment projections previously described, it appears that about 666,000 persons will graduate from post-secondary technician training programs over the 1963-74 period. (See table 10.)

New Entrants. Not all graduates of post-secondary preemployment programs obtain work as technicians. Some graduates continue their education in a 4-year college or university. Others accept jobs in occupations classified as "skilled" where they use only part of their training, or in technician jobs in the medical and dental fields, which are excluded from this study.

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87/ These estimates were based largely on Office of Education data for the 1956-1962 period available in Organized Occupational Curriculums in Higher Education, Reports for 1956, 1958, and 1962; and annual reports of progress under Title VIII of the NDEA. The ratio of graduates to total enrollments rather than to first-year students was made because historical data on the number of new students each year are not available.

88/ This does not imply that the proportion of first-year students who graduate from well-established programs is lower than that for new programs. It simply reflects the large and rapidly growing number of first-year enrollments usually associated with new programs. For example, if first-year and second-year classes are identical in size and all second-year students graduate, the proportion of graduates to enrollments would be one-half. However, the first-year classes in new schools are generally larger than the second-year class, thereby lowering this proportion.

Based on information in several follow-up studies of graduates of these programs, 89/ it was estimated that about 65 percent of all graduates of post-secondary technician training programs in 1963 entered technician jobs. The assumption was made that the proportion of graduates entering technician jobs would remain roughly the same over the 1963-74 period. Thus, of the estimated total of 666,000 graduates over the 1963-74 period, about 434,000 are expected to enter technician jobs. On an annual basis, the number of entrants from graduates of post-secondary technician training programs is expected to more than triple over this period, rising from 16,200 in 1963 to 53,500 in 1974.

Projections of enrollments, graduates, and new entrants, are based on limited data and reflect many judgments and assumptions about future trends. If any of the underlying assumptions and estimates were to be changed significantly, the estimates of people entering the occupation also would change. For example, if enrollments in post-secondary preemployment technician training programs should increase in line with the inordinately rapid increases recorded between 1960 and 1963, such enrollments could average nearly 225,000 a year during the 1963-74 period, and the number of graduates, nearly 70,000. 90/ This would mean that over 500,000 persons would qualify for technican jobs through post-secondary occupational programs, as compared with the 434,000 projected. 91/ Nevertheless, the intermediate projects appearing in table 10 represent the best judgment as to what may happen in the years ahead.

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89/ These follow-up studies include Placemnt of Graduates from Technical Education Preparatory Programs, Fiscal Year 1963, Title VIII of the National Defense Education Act of 1958, Technical Education Branch, Division of Vocational and Technical Education Assistant Programs, U.S. Office of Education; Progress in Technical Vocational Education Programs, op. cit., Graduate Survey, 1961, Halifax State Technical Institute: A Preliminary Survey of Graduates of the Pennsylvania State University with the Degree of Associate in Engineering. Classes of 1955 through 1961, Their Progress on the Job, July 16, 1962.

90/ In deriving this projection, only the assumption concerning the number of enrollments differend from the assumptions underlying the projection previously discussed.

91/ The end of this chapter presents a summary of the projections of supply under primary assumptions and illustrative estimates of what might occur under alternate assumptions.

Table 10. New Entrants from Post-secondary Preemployment Technician Training Programs, 1963-74

| Academic year | Number enrolled | Number graduating | Number entering technician occupations |
|---|---|---|---|
| 1962-63---------- | 90,700 | 24,900 | 16,200 |
| 1963-64---------- | 99,900 | 27,500 | 17,900 |
| 1964-65---------- | 119,800 | 32,900 | 21,400 |
| 1965-66---------- | 153,000 | 42,800 | 27,800 |
| 1966-67---------- | 178,300 | 50,800 | 33,000 |
| 1967-68---------- | 191,600 | 55,600 | 36,100 |
| 1968-69---------- | 206,300 | 60,900 | 39,600 |
| 1969-70---------- | 222,900 | 66,900 | 43,500 |
| 1970-71---------- | 230,200 | 70,200 | 45,600 |
| 1971-72---------- | 240,100 | 74,400 | 48,400 |
| 1972-73---------- | 249,200 | 78,500 | 51,000 |
| 1973-74---------- | 257,100 | 82,300 | 53,500 |
| Total 1963-74 | 2,239,000 | 667,700 | 434,000 |
| Annual average | 186,600 | 55,600 | 36,200 |

Note: Because of rounding the sum of individual items may not equal totals.

## New Entrants with Industry Training

Industry training of technicians is provided usually by employers who either cannot obtain a sufficient number of trained technicians from other sources to meet their needs, or who require technicians in a field of specialization not readily available to the company. Such training is given on the job, and is generally supplemented with classroom instruction.

The lack of comprehensive data on industry training makes the number of technicians trained by industry extremely difficult to project. Based on field interviews and on the results of surveys of employer's future training plans conducted by State employment security agencies (area skill surveys), 92/ it appears that the number of technicians trained by industry varies according

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92/ For a list of several of these surveys, see appendix D.

to the number of trained personnel available from other formal sources of supply. Available information indicates that employers anticipate doing a decreasing amount of technician training. Many reasons are cited. For example, employers feel that the costs of training a technician in a company program are too high, or that their needs will be met through other sources, mainly from post-secondary preemployment training programs.

To project the number of technicians who will qualify for their jobs through industry training programs, a detailed analysis was made of all the area skill surveys containing current estimates and projections of industry training. Employer estimates of the number of technicians being trained in the company (most of the surveys are based on 1962 employment) were related to total hires by the company in that year to determine the proportion of total hires trained in industry programs. The proportion thus derived was then related to the total number of persons estimated to have entered technician jobs in the base year 1962, to determine industry training of technicians in that year. The surveys also indicated that employers plan to decrease the amount of training in the future at a rate of about 2 percent a year. Therefore, in order to project industry training of technicians, it was assumed that industry training would slowly decrease over the 1962-74 period.

There are major weaknesses in this method of estimating industry training of technicians. One is that many employers have projected their training activities by relating estimates of future needs and anticipated supply from all other formal sources. If employers misjudged the future supply available to them, their training activities will be considerably different than those estimated in the area skill surveys. Another weakness is that projections appearing in the surveys are for periods of no more than 5 years. None of the projections extend to 1975, and most cover a period ending in the late 1960's. Nevertheless, the projections of technicians trained by industry (illustrated in table 11) appear reasonable, and are consistent with information obtained in field interviews and trends in other data gathered for the preparation of these supply estimates. 93/

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93/ For example, an examination of the trend in the number of technicians (draftsmen and designers) who complete training in programs registered with the Bureau of Apprenticeship and Training indicates that this number has declined appreciably between 1958 and 1963.

Table 11. New Entrants with Industry Training, 1963-74

| Year | Technicians to be trained by employers |
|---|---|
| 1963 | 21,600 |
| 1964 | 21,200 |
| 1965 | 20,800 |
| 1966 | 20,400 |
| 1967 | 19,900 |
| 1968 | 19,500 |
| 1969 | 19,200 |
| 1970 | 18,800 |
| 1971 | 18,400 |
| 1972 | 18,000 |
| 1973 | 17,700 |
| 1974 | 17,300 |
| Total 1963-74 | 232,800 |
| Annual average | 19,400 |

New Entrants from MDTA Training Programs

Preemployment technician training offered in MDTA training programs stresses applied technical courses, and a great majority of these courses qualify students for draftsmen positions. However, because such training has been given only since passage of the MDTA in 1962, historical data upon which to base projections of the number of workers who will enter technician occupations after completing this type of technician training are limited.

Projections of the number of persons expected to qualify for technician occupations through MDTA training were based on estimates of the number of persons expected to register for such programs. 94/ Indications are that the total number of trainees will grow steadily until the latter part of the 1960's, and then remain relatively unchanged through 1974. Since the inception of these programs, persons trained specifically for technician positions have amounted to about 2 percent of all MDTA trainees, and in estimating the number of future technician trainees, it was assumed that this proportion would not change significantly.

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94/ These are unpublished estimates which were the latest available at the time this report was prepared.

As with other types of training, not all trainees who begin MDTA training programs complete them. Trainees leave for many reasons, including financial, illness, and lack of interest. 95/ Also, not all those completing the training programs will enter the specific technician occupation for which they were trained. Of all MDTA technician trainees in 1963 and 1964, an estimated 70 percent completed such training; of those completing training, about 65 percent entered technician occupations. 96/ Projections of the number of those completing MDTA technician training programs were made by applying the completion rates to projections of registrations in these programs. On this basis, it is estimated that over the 1964-74 period, 97/ an average of 3,700 graduates of these programs would enter technician jobs each year. (See table 12.)

Table 12. New Entrants from MDTA Technician Training Programs, 1964-74 1/

| Year | Number registered in technician training programs | Number completing technician training programs | Number entering technician jobs |
|---|---|---|---|
| 1964 | 2,500 | 1,700 | 1,100 |
| 1965 | 4,000 | 2,800 | 1,800 |
| 1966 | 5,500 | 3,900 | 2,500 |
| 1967 | 7,500 | 5,300 | 3,400 |
| 1968 | 10,000 | 7,000 | 4,600 |
| 1969 | 10,000 | 7,000 | 4,600 |
| 1970 | 10,000 | 7,000 | 4,600 |
| 1971 | 10,000 | 7,000 | 4,600 |
| 1972 | 10,000 | 7,000 | 4,600 |
| 1973 | 10,000 | 7,000 | 4,600 |
| 1974 | 10,000 | 7,000 | 4,600 |
| Total 1964-74 | 89,500 | 62,600 | 40,700 |
| Annual average | 8,100 | 5,700 | 3,700 |

1/ Only small numbers entered from MDTA programs prior to 1964.

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95/ Although some trainees may leave these programs before completing training in order to take a job as a technician, this number is believed to be very small.

96/ Estimates are based on data appearing in Manpower Research and Training Under the Manpower Development and Training Act, a report by the Secretary of Labor, Transmitted to Congress, March 1964, and Manpower Research and Training Under the Manpower Development and Training Act of 1962, a report by the Secretary of Labor, March 1965.

97/ Only small numbers entered from MDTA programs prior to 1964.

## New Entrants from Technician-Related Training

### New Entrants with College and University Degrees

College and university science and engineering curriculums leading to the bachelor's degree provide training that qualifies many people for technician jobs. In 1963, about 10 percent of all technicians had a college degree. 98/ Although many of these people obtained their degree after first working as a technician, evidence indicates that a large number first obtained a college degree, most likely in a technical field.

The projections of new entrants with college degrees comprise two parts: (1) Projections of new college graduates with a bachelor's degree, by field of study; and (2) estimates of the proportion of these new graduates who will enter technician occupations. The projections of college graduates used were those prepared by the U.S. Office of Education. 99/ These projections assume a continuation of current trends in the proportion of the population attending college and in the proportion of college students studying particular fields.

Only a very small proportion of college graduates work as technicians. Because the number of college graduates entering technician occupations varies among different fields of studies, separate entrance rates were developed for graduates of engineering, science, and other fields. 100/ In the past, entry rates of college graduates into technician jobs varied from a low of less than 1 percent of those with bachelor's degrees in engineering, to a high of 15 percent of those with degrees in architecture. 101/ To project the number of college graduates who will enter technician occupations, these entrance rates were applied to the projections of college degrees by field, described earlier. (See table 13.)

A primary assumption underlying these projections is that the proportion of college graduates entering technician jobs over the 1963-74 period will not be significantly different from those of the past. However, even if the proportion should change significantly, the effect on the total supply of technicians would be slight because of the relatively small number of persons involved.

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98/ Based on data in the Postcensal Study. (See table 4.)

99/ See Earned Degrees by Field of Study and Level Projected to 1975, (U.S. Department of Health, Education, and Welfare, Office of Education), OE 54031. These were the most current Office of Education projections at the time this study was prepared.

100/ Information appearing in Two Years After the College Degree, Work and Further Study Patterns, National Science Foundation 1963, was used to develop entrance rates. The study presents data on the working activity of 1958 graduates in 1960.

101/ A relatively large proportion of architectural graduates enter draftsmen occupations.

Table 13. New Entrants from College and University Graduates, 1963-74

| Year | Entrants with a college degree in science, engineering, and architecture | Entrants with a college degree in fields other than science, engineering and architecture | Total entrants with a college degree |
|---|---|---|---|
| 1963 | 2,200 | 1,100 | 3,300 |
| 1964 | 2,400 | 1,100 | 3,600 |
| 1965 | 2,600 | 1,300 | 3,800 |
| 1966 | 2,600 | 1,300 | 3,900 |
| 1967 | 2,800 | 1,400 | 4,200 |
| 1968 | 3,400 | 1,600 | 5,000 |
| 1969 | 4,000 | 1,900 | 5,800 |
| 1970 | 4,000 | 1,900 | 5,900 |
| 1971 | 4,000 | 1,900 | 5,900 |
| 1972 | 4,200 | 1,900 | 6,100 |
| 1973 | 4,400 | 2,000 | 6,300 |
| 1974 | 4,600 | 2,100 | 6,700 |
| Total 1963-74 | 41,000 | 19,500 | 60,500 |
| Annual average | 3,400 | 1,600 | 5,000 |

Note: Because of rounding the sum of individual items may not add to totals.

## New Entrants from College Students not Completing Four-Year College and Engineering and Science Curriculums

Training provided in the first two years of both engineering and science curriculums is sufficient to prepare a young person for some entry technician jobs. Engineering students who do not complete their college education, however, are more likely to pursue technician work than are science majors because they generally take fewer applied technology courses and are less able to meet requirements for technician entry jobs. Also, there are fewer technician jobs for those with science specialties according to estimates based on the Postcensal Study. 102/

Estimates of dropouts from engineering and science curriculums in recent years were made by first analyzing the relationship between first through fourth year enrollments in and graduations from engineering and science curriculums, including such factors as annual transfers to and from

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102/ In the Postcensal Study, over 50 percent of all technician jobs are in the engineering fields.

other curriculums. To develop the projections of dropouts, the assumption was made that the same proportion of each years class would fail to complete college in the 1963-74 period as did in recent years. On this basis, an average of over 10,000 engineering students and over 25,000 science students are projected to drop out of college each year during the 1963-74 period, theoretically all these will have sufficient training to qualify for technician jobs.

Estimates of the number who would enter technician occupations were then developed from follow-up studies of college dropouts. 103/ Based on data in these studies, it is estimated that about 5 percent of the science curriculum dropouts and 25 percent of the engineering curriculum dropouts enter technician occupations immediately after leaving college. On this basis, a total of about 47,000 persons are projected to enter technician occupations between 1963 and 1974 after completing 2 or 3 years of an engineering or science curriculum. (See table 14.)

Table 14. New Entrants with Some College Training in Engineering and Science, but without a Degree, 1963-74

| Year | New entrants with engineering training | New entrants with science training | Total new entrants with engineering and science |
|---|---|---|---|
| 1963 | 2,000 | 800 | 2,800 |
| 1964 | 2,100 | 900 | 3,000 |
| 1965 | 2,000 | 900 | 2,900 |
| 1966 | 2,400 | 900 | 3,400 |
| 1967 | 2,800 | 1,000 | 3,800 |
| 1968 | 2,900 | 1,200 | 4,200 |
| 1969 | 2,900 | 1,500 | 4,400 |
| 1970 | 2,900 | 1,500 | 4,400 |
| 1971 | 2,900 | 1,500 | 4,500 |
| 1972 | 3,000 | 1,600 | 4,600 |
| 1973 | 3,100 | 1,700 | 4,800 |
| 1974 | 3,200 | 1,800 | 5,000 |
| Total 1963-74 | 32,300 | 15,400 | 47,600 |
| Annual average | 2,700 | 1,300 | 4,000 |

Note: Because of rounding the sum of individual items may not equal totals.

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103/ A Follow-Up Study of Engineering Dropouts, University of Missouri, 1947-52, The University of Missouri Bulletin, Vol. 57, No. 1, Educational Series No. 59; Retention and Withdrawal of College Students, 1958, Bulletin No. 1, Office of Education, "Engineering Students Dropouts," Report on the ASSEE Sub-Committee on "Dropouts of Engineering Students," Journal of Engineering Education, April, 1960.

## New Entrants with Training in the Armed Forces

Large numbers of young people have received technician-related training while on active duty with the Armed Forces. According to one recent study, for example, 104/ nearly one-fourth of all engineering and physical science technicians reported that part of their occupational training was received in the military service. Similar findings appear in other studies. 105/ However, military training usually does not include enough theory to permit discharges to enter directly into most civilian technician jobs without additional training. Consequently, the number of men separated from the Armed Forces with some technician training is very large relative to the total number of these discharges who actually enter civilian technician jobs.

Projections of the number of new entrants having Armed Forces training were made by estimating the number of persons with technician-related training to be separated from the Armed Forces each year, and applying an estimate to the proportion of these who will enter civilian technician jobs without taking additional training. Although it has been assumed, for purposes of this study, the size of the Armed Forces will be roughly the same in 1974 as in 1963, the number of technicians trained by the military services, particularly electronic technicians (the large majority of all military technicians) is expected to increase between 1963 and 1974, probably at about the same rate as in the recent past. Underlying this growth is the expected further increase by the Armed Forces in the use of electronic systems, 106/ and a concomitant increase in the number of technician-trained personnel.

An early BLS study 107/ indicated that about 7 percent of all electronic technicians had no training other than Armed Forces training directly prior to entering their civilian technician job. Thus, if about 7 percent of the estimated 14,000 new electronic technicians in 1963 were to have had military training as their primary educational qualification, this would mean that about 1,000 of the estimated 34,000 separations with Armed Forces technical training in 1963 entered technician jobs, or about 3 percent of the

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104/ The Formal Occupational Training of Adult Workers, (U.S. Department of Labor, Office of Manpower, Automation and Training, Manpower Automation Research Monograph No. 2, December 1963.)

105/ The Mobility of Electronics Technicians (BLS Bulletin 1150, 1954) and information in the Postcensal Study, op. cit.

106/ From the end of World War II through Fiscal Year 1962, the number of personnel employed in electronics occupations increased from 6.0 percent to 13.8 percent of total enlistments. (The Changing Patterns of Military Skill), Employment Security Review, U.S. Department of Labor, Bureau of Employment Security, July 1963.)

107/ The Mobility of Electronic Technicians, op. cit.

separations. 108/ Despite the roughness of this approach, the resulting estimates are believed to represent the correct order of magnitude, and are corroborated by information obtained from field interviews and data obtained from an Air Force follow-up survey of technicians who left the service. 109/

The potential supply of technicians trained in the Armed Forces far exceeds the number actually believed to enter civilian technician jobs. If a larger proportion of those with technical training in the Armed Forces could qualify for civilian jobs in the future--as a result of changing employer requirements or more intensive Armed Forces training--or if the size of the Armed Forces were to increase significantly, the number of entrants from the Armed Forces would increase substantially making this source of supply considerably more important. On the other hand, if the proportion of those technically trained dischargees obtaining civilian technician jobs should decrease, no significant change would be registered in the total number of entrants into technician occupations, since the estimate of entrants with Armed Forces training is a relatively small part of the total of all entrants projected over the 1963-74 period. However, this source of training potentially could provide a large number of technicians for the civilian economy.

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108/ Adjustments were made to reflect the fact that there is no way to estimate the number of military technicians entering civilian technician jobs who were civilian technicians prior to military service.

109/ Contributions of the Armed Forces to Training and Education: Statement by Harold Wool, Office of Assistant Secretary of Defense before the President's Committee on Education before the high school, January 1957.

On the basis of the information just presented, it was estimated that the number of technicians entering civilian jobs directly after receiving training in the Armed Forces would average about 1,300 a year, as shown in table 15.

Table 15. New Entrants with training in the Armed Forces, 1963-74

| Year | Total separations from Armed Forces technical work | Number entering civilian technical jobs |
|---|---|---|
| 1963 | 34,000 | 1,000 |
| 1964 | 39,400 | 1,200 |
| 1965 | 43,500 | 1,300 |
| 1966 | 46,000 | 1,400 |
| 1967 | 44,400 | 1,300 |
| 1968 | 44,700 | 1,300 |
| 1969 | 45,000 | 1,400 |
| 1970 | 45,400 | 1,400 |
| 1971 | 45,800 | 1,400 |
| 1972 | 46,700 | 1,400 |
| 1973 | 46,500 | 1,400 |
| 1974 | 46,500 | 1,400 |
| Total 1963-74 | 528,900 | 15,800 |
| Annual average | 44,100 | 1,300 |

### Summary of Supply from Preemployment and Technician-Related Training, 1963-74

Not all those who enter technician jobs from preemployment or technician-related training each year over the 1963-74 period will still be in the field in 1975. Many will transfer to other fields of work and significant numbers will leave the field as a result of retirements and deaths. Using the tables of working life to develop death and retirement rates and estimating that 3 percent of all employed technicians leave the field each year to transfer to other occupations, 110/ it is estimated that of the projected 832,000 new entrants from formal sources between 1963 and 1974, about 675,000 will still be in the profession in 1975. Table 16 presents estimates of the future annual supply of new technicians who will remain in the field in 1975 after allowances for deaths, retirements, and transfers.

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110/ See chapter IV, p. 52, for further information on the estimated transfer rate.

Table 16. Net Supply of New Entrants from Preemployment and Technician-Related Training, 1963-74

| Year of entrance | Survivors in 1975 |
|---|---|
| 1963 | 27,700 |
| 1964 | 31,100 |
| 1965 | 35,400 |
| 1966 | 42,300 |
| 1967 | 48,800 |
| 1968 | 54,900 |
| 1969 | 60,600 |
| 1970 | 66,000 |
| 1971 | 70,100 |
| 1972 | 75,100 |
| 1973 | 80,300 |
| 1974 | 85,700 |
| Total, 1963-74 | 677,900 |
| Annual average | 56,500 |

Source: Tables 1-6, minus deaths, retirements, and transfers.

## Alternative Projections of Supply

In addition to the intermediate projection of the supply from preemployment and technician-related training, projections are also developed for a "high" and a "low" supply situation. These estimates take into account variations in the assumptions underlying the supply estimates. In table 8, estimates of "high" supply from all sources and estimates of "low" supply from all sources have been aggregated. This does not mean to imply that all "low" estimates or all "high" estimates would occur at the same time. This aggregation is presented merely to illustrate the range of estimates of supply that might occur under the alternative projections of supply developed in this report.

As table 17 shows, estimates of the gross supply of technicians with preemployment or technician-related training under the "low" estimates was 575,700, as compared with 832,000 in the intermediate projections. Thus, the annual average increment to supply would be about 48.000 a year under the "low" estimate, as compared with about 69,300 in the intermediate projection. The "high" projection shows a gross supply from formal sources of training of 1,259,700, or about 105,000 a year, on the average.

Table 17. "High," "Intermediate," and "Low" Projections of the Supply of Technicians from Preemployment and Technician-Related Training, 1963-74

| Source of training | High | | Intermediate | | Low | |
|---|---|---|---|---|---|---|
| | Total | Annual average | Total | Annual average | Total | Annual average |
| Post-secondary preemployment curriculum---------------------------- | 522,800 | 43,600 | 434,000 | 36,200 | 286,800 | 23,900 |
| MDTA programs---------------------- | 61,100 | 5,600 | 40,700 | 3,700 | 30,500 | 2,800 |
| College and university graduates---- | 74,100 | 6,200 | 60,500 | 5,000 | 46,400 | 3,900 |
| College and university dropouts----- | 104,200 | 8,700 | 47,600 | 4,000 | 28,600 | 2,400 |
| Armed Forces separations------------ | 60,600 | 5,100 | 15,800 | 1,300 | 8,800 | 700 |
| Employer training------------------- | 436,900 | 36,400 | 232,800 | 19,400 | 174,600 | 14,500 |
| Total--all sources | 1,259,700 | 105,000 | 832,000 | 69,300 | 575,700 | 48,000 |

**Notes:** It does not necessarily follow that all lows would occur together and all highs together as illustrated in this table. Any combination of high, low, or primary estimates among the 6 sources is possible. However, the totals shown illustrate the wide range of possible supply totals.

Because of rounding the sum of individual items may not add to totals.

As presented in the earlier discussion of intermediate supply, not all those who enter technician occupations between 1963 and 1974 will still be in the field in 1975. Using the tables of working life and the estimates of transfer losses described earlier, estimates were derived of the number of new entrants with preemployment or technician-related training who are expected to remain in the technician workforce in 1975. Under the aggregated "high" projections, it is estimated that nearly 1,040,000 of the projected 1,259,700 will be in the occupation in 1975. Under the "low" projection, of all new entrants from 1963-1974, about 475,000 will still be in the technician workforce in 1975.

## Chapter VI. Assessment of Supply and Demand Projections

The interrelationships of the intermediate, high, and low projections of requirements and supply present a wide range of possible supply-demand conditions. 111/ Furthermore, the pattern of interrelationship of supply and demand will itself affect the magnitudes of both supply and demand. For example, it is unlikely that a "high" demand for technicians would exist together with a "low" supply of technicians for long periods of time, since company training programs and other types of training would most likely be increased to meet the needs for these personnel, or companies would adjust operations to reduce the need, or offer more compensation to increase the supply. The discussions of the alternative projections merely attempt to present the reader with illustrations of several of the many possible supply-demand conditions which would result if the assumptions underlying either the supply or requirement projections were to be changed. The supply-demand situation which is believed to be most likely to occur combines the "intermediate" supply projection with the "intermediate" requirements projection, and special attention has been given to this combination.

Under the "intermediate" 1975 requirement projections for technicians in 1975, about 1,025,000 new technicians may be needed over the 1963-75 period--an average of about 86,000 a year. This estimate includes estimated needs for 645,000 technicians as a result of growth, and for 380,000 technicians to replace those technicians employed in 1963 who will retire, die, or transfer to other fields of work by 1975. The "intermediate" projections of supply for the 1963-74 period indicate that preemployment training programs, including programs in 2-year schools, industry, and under the Manpower Act, and technician-related training in colleges and universities, and in the Armed Forces, may provide a net of about 675,000 technicians by 1975--an average of about 56,500 annually.

A comparison of these requirements and supply projections implies that, to meet total needs, employers would have to upgrade about 425,000 workers, or an average of about 35,000 annually during the 1963-74 period. 112/ Upgrading of this magnitude, though relatively large, appears to be in line with historical evidence, which indicates that in recent years an average of about 40,000 workers were upgraded to technician occupations to meet the requirements. Furthermore,

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111/ The "intermediate," "high," and "low" projections of supply, as influenced by the various assumptions, are those presented in chapter V, table 8. The "intermediate," "high," and "low" requirement projections are those presented in chapter IV.

112/ This is a gross figure which includes replacements for those technicians who are upgraded during the 1963-75 period, but who would die, retire, or transfer to other jobs by 1975. The net figure of upgrading needs is about 350,000 (1,025,000 demand minus 675,000 supply equals 325,000). See footnote 79.

since the number of technicians trained specifically for technician jobs is expected to increase sharply, there will be a significant increase in the proportion of highly trained technicians. For example, in recent years, new entrants with preemployment training represented only about two-fifths of all entrants whereas over the 1963-74 period such entrants are projected to average over two-thirds of all new entrants.

The relationship of the supply of and demand for all technicians under the "intermediate" assumptions should not be construed as an indication that the supply-demand situation within each technician specialty will be the same. Employers indicate that because of the growing complexity of industrial technology and research activities and the high calibre of the scientists and engineers now being trained in our Nation's colleges, it has become increasingly difficult to upgrade workers into technician jobs in certain fields of technology. Thus, it is fairly likely that the demand may exceed the supply in those fields requiring highly trained technicians.

Also, the relationship of the supply of and demand for technicians in 1975 under the intermediate projections does not mean to imply an unchanging supply-demand situation throughout the 1963-75 period. During the first few years of this period, a larger proportion of technician requirements will have to be filled by employer upgrading if demands are to be met. The number of technicians available from preemployment programs is not expected to increase substantially until the latter part of the 1960's and 1970's.

Effects of Alternative Assumptions

Alternate Supply Projections. Under the "high" projection of technician supply from preemployment and technician-related training, the net number of new entrants from these programs would be about 1,026,000 during the 1963-74 period. (See table 18.) Should this projection be realized, and should the needs for technicians approximate those described under the "intermediate" projection of requirements (a total need for about 1,025,000 new technicians between 1963 and 1975) the number of trained technicians available would equal requirements. Although this rough balance would imply that total requirements could be filled completely by trained technicians, and thus there would be no need to upgrade other workers into technician jobs, some employers would undoubtedly continue to meet at least part of their needs through upgrading. Many firms feel that some technician jobs requiring manual abilities can better be filled through upgrading of skilled workers, and many would continue to prefer to do this rather than hire trained technicians. Furthermore, some firms might not be willing or able to pay the going wage for trained technicians. As a result of this continued upgrading at a time when the supply of trained technicians would be adequate for all needs, technicians trained in some types of work and in some areas with large training facilities might face strong competition for positions.

On the other hand, should the projections of a "low" supply from preemployment or technician-related training be realized, a net of about 469,000 technicians would be forthcoming during the 1963-75 period. To meet the "intermediate" requirement projections, employers would then have to upgrade about 682,000 workers during the 1963-75 period--an average of about 56,800 workers a year. Upgrading of this magnitude, which would substantially exceed the amount of upgrading done in the recent past, might be very difficult to accomplish. Furthermore, upgrading this number of workers into technician jobs would lower considerably the proportion of technicians with preemployment training, thus possibly lowering the quality of the technician work force.

Alternative Demand Projections. If requirements should increase to the levels indicated by the "high" projection, about 1,290,000 new technicians would be needed during the 1963-75 period. (See table 18.) Relating this projection to the various supply projections results in vastly different supply-demand situations.

Under the "intermediate" supply projections, about 745,000 technicians would have to be upgraded during the 1963-74 period--an average of about 62,000 a year. (See table 18.) As with the "low" supply estimates, upgrading of this magnitude might seriously affect the quality of the technician work force, and it is highly probable that employers would not be able or satisfied to upgrade this number of persons and would seek other solutions. On the other hand, if supply should increase to the level indicated by the "high" supply projection, then employers would have to upgrade only about 318,000 technicians during the 1963-74 period, or about 26,500 a year. Thus, under the "high" projections of requirements, technician needs could be effectively met only if there was a relatively high supply of new entrants from more formal sources.

Under assumptions which result in a "low" demand for technicians, about 887,000 new technicians would be required between 1963 to 1975. The "intermediate" projections of supply indicate that only about 251,000 technicians would have to be upgraded over the 1963-74 period, an average of about 20,900 a year; this would result in a substantial improvement in the quality of technician work force. An even greater improvement in the qualifications of the work force would exist, of course, under conditions of a "high" supply. If supply should increase only to the levels indicated by the "low" projection, employers would have to upgrade about 507,000 technicians over the 1963-74 period--about 42,300 a year. On balance, if requirements for technicians reach the "low" estimate, the qualifications of the work force would improve over the 1963-75 period regardless of the supply condition, since a smaller number of workers would have to be upgraded in all three situations. However, this is not meant to imply that this would necessarily be a desirable situation, since "low requirements" for technicians would be at the cost and as a result of a slow down in our economic growth and scientific advancement.

Table 18. "High," "Intermediate," and "Low" Projections of Technician Requirements and Supply, 1963-75

| Level of supply | Total manpower needs 1963-75 | Supply with preemployment or technician-related training 1963-75 | Upgrading needs 1963-75 1/ |
|---|---|---|---|
| | "High" requirements | | |
| "High" supply------------------ | 1,290,000 | 1,026,000 | 318,000 |
| "Intermediate" supply---------- | 1,290,000 | 678,000 | 745,000 |
| "Low" supply------------------- | 1,290,000 | 469,000 | 1,002,000 |
| | "Intermediate" requirements | | |
| "High" supply------------------ | 1,025,000 | 1,026,000 | --- |
| "Intermediate" supply---------- | 1,025,000 | 678,000 | 426,000 |
| "Low" supply------------------- | 1,025,000 | 469,000 | 682,000 |
| | "Low" requirements | | |
| "High" supply------------------ | 887,000 | 1,026,000 | --- |
| "Intermediate" supply---------- | 887,000 | 678,000 | 251,000 |
| "Low" supply------------------- | 887,000 | 469,000 | 507,000 |

1/ Including estimated needs for those upgraded from 1963-75 who would retire, die, or transfer to other occupations by 1975.

## Training Implications

In assessing the projections of supply and demand developed in this report, great care should be exercised in evaluating the projections of the new supply of technicians from graduates of post-secondary preemployment technician training programs offered in technical institutes, junior colleges, and area vocational-technical schools. No matter what the demand for technicians, graduates of these programs are expected to be the most adequately trained source of technician supply and will be the type of technician in greatest demand. Nevertheless, if demand does not reach the levels implied by the "intermediate" projections, there could be some difficulty in placing some graduates of these programs in desirable positions, particularly in those sections of the Nation with large training facilities. On the other hand, if the number of graduates does not increase as greatly as projected in the "intermediate" or "high" estimate, the quality of the technician workforce might be lowered because of the large number of upgradings required.

The "intermediate" projections of supply and demand imply that post-secondary preemployment curriculums will not be able to supply a sufficient number of new entrants over the 1963-75 period to meet the total demand for technicians. Thus, in this situation, good opportunities in technician jobs would exist for persons completing Government preemployment training programs, for persons with technician training separated from the Armed Forces, for college graduates, and for students finishing 2 years of a 4-year college course in engineering or science. Furthermore, workers in technician related jobs who do not have specific training for technician work would also have very good opportunities, although entrance into the technician field may become more and more difficult as technician work become more complex, and promotional opportunities may be more limited.

It should be emphasized that the projections of graduates of pre-employment post-secondary curriculums reflect large increases in technician training consistant with current and anticipated plans. At the time this report was written, funds available for such training were increased greatly over the levels of the early 1960's, and it has been assumed that the rise in the number of persons trained would continue to accompany an increase in funds. However, if students are not attracted to these programs, or if teachers and or facilities for training are not made available as assumed, or if leadership is not provided to develop these training programs, the projections of graduates of post-secondary preemployment training programs would be affected accordingly, with serious effects on the quality of the work force.

## Appendix A. Statistical Tables

In the following tables, absolute figures usually are rounded and percentages shown to one decimal place. Presentation of the figures in this form should not be construed as indicating that they have exactly this degree of precision.

Since all totals and percentages were calculated on the basis of unrounded figures, they do not always correspond exactly with those indicated by rounded figures on the tables.

Table A-1. Estimated Employment of Technicians, by Occupation and Industry, 1963

| | Total technicians | Draftsmen | Engineering and physical science technicians | | | | | | Life science technicians | All other technicians |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Engineering technicians | Chemical technicians | Physics technicians | Mathematics technicians | Other physical science technicians | | |
| All Industries | 844,800 | 232,000 | 439,000 | 308,500 | 64,600 | 10,800 | 6,100 | 49,000 | 58,100 | 115,700 |
| Mining (including petroleum) | 13,800 | 4,000 | 6,700 | 2,200 | 500 | 100 | (1/) | 3,900 | 100 | 3,000 |
| Construction | 29,500 | 13,700 | 11,000 | 10,300 | 300 | 100 | 100 | 300 | 200 | 4,600 |
| Manufacturing | 389,700 | 122,800 | 207,500 | 148,100 | 35,300 | 4,700 | 2,100 | 17,300 | 8,900 | 50,600 |
| Ordance and accessories | 19,300 | 4,500 | 12,800 | 10,500 | 800 | 600 | 200 | 700 | (1/) | 1,900 |
| Food and kindred products | 11,100 | 700 | 5,700 | 2,200 | 3,200 | (1/) | (1/) | 300 | 2,300 | 2,400 |
| Textile mill products and apparel | 2,900 | 300 | 1,500 | 700 | 700 | (1/) | (1/) | 100 | (1/) | 1,200 |
| Lumber and furniture | 9,000 | 4,300 | 1,600 | 1,100 | 500 | (1/) | (1/) | (1/) | 400 | 2,700 |
| Paper and allied products | 6,400 | 2,000 | 3,400 | 2,000 | 1,200 | (1/) | (1/) | 100 | 100 | 900 |
| Chemicals and allied products | 38,400 | 3,300 | 24,500 | 6,800 | 15,200 | 400 | 200 | 1,900 | 4,300 | 6,200 |
| Petroleum refining and products of petroleum and coal | 6,700 | 1,100 | 4,200 | 1,800 | 1,500 | (1/) | (1/) | 900 | 100 | 1,400 |
| Rubber products | 5,500 | 1,400 | 3,000 | 1,700 | 1,100 | (1/) | (1/) | 200 | (1/) | 1,000 |
| Stone, clay, and glass products | 5,800 | 1,500 | 2,700 | 1,700 | 800 | 100 | (1/) | 100 | (1/) | 1,500 |
| Primary metal products | 16,500 | 4,100 | 9,800 | 3,900 | 1,200 | 100 | (1/) | 4,500 | 100 | 2,500 |
| Fabricated metal products | 26,300 | 16,700 | 6,600 | 5,400 | 500 | 100 | 100 | 500 | (1/) | 3,000 |
| Machinery, except electrical | 61,700 | 28,300 | 25,700 | 21,800 | 1,400 | 500 | 400 | 1,600 | 100 | 7,600 |
| Electrical equipment | 98,800 | 27,400 | 64,000 | 54,900 | 3,600 | 1,800 | 600 | 3,000 | 100 | 7,300 |
| Aircraft and parts | 35,200 | 9,000 | 22,300 | 18,600 | 1,200 | 400 | 300 | 1,700 | 100 | 3,800 |
| Motor vehicles and equipment | 13,500 | 6,100 | 5,200 | 4,100 | 300 | 100 | (1/) | 700 | 100 | 2,100 |
| Other transportation equipment | 6,700 | 4,500 | 1,900 | 1,700 | 100 | (1/) | (1/) | 100 | (1/) | 300 |
| Professional and scientific instruments | 20,600 | 5,200 | 10,800 | 7,900 | 1,500 | 400 | 100 | 1,000 | 900 | 3,700 |
| Miscellaneous manufacturing | 5,400 | 2,500 | 1,800 | 1,200 | 500 | (1/) | (1/) | 100 | 100 | 1,100 |
| Transportation, communication, and electric, gas, and sanitary services | 55,200 | 7,900 | 37,200 | 34,100 | 1,400 | 300 | 200 | 1,200 | 300 | 9,900 |
| Transportation | 8,200 | 2,100 | 3,900 | 3,400 | 300 | (1/) | (1/) | 200 | 100 | 2,100 |
| Communication | 29,200 | 800 | 23,500 | 22,100 | 600 | 200 | 100 | 400 | (1/) | 4,900 |
| Electric, gas, and sanitary services | 17,900 | 5,000 | 9,900 | 8,600 | 500 | 100 | 100 | 600 | 200 | 2,900 |
| Other industries | 176,800 | 59,300 | 66,700 | 42,100 | 14,100 | 2,600 | 2,200 | 5,700 | 25,500 | 35,300 |
| Miscellaneous business services | 39,100 | 11,300 | 20,300 | 12,600 | 4,000 | 1,000 | 600 | 2,100 | 1,100 | 6,400 |
| Medical and dental laboratories | 16,200 | (1/) | (1/) | --- | (1/) | --- | --- | --- | 15,800 | 400 |
| Nonprofit organizations | 13,100 | 1,600 | 7,900 | 1,700 | 3,600 | 700 | 200 | 1,600 | 3,600 | 100 |
| Engineering and architectural services | 68,200 | 43,300 | 11,500 | 10,200 | 400 | 200 | 100 | 700 | (1/) | 13,400 |
| All other nonmanufacturing | 40,100 | 3,100 | 27,000 | 17,700 | 6,100 | 600 | 1,400 | 1,300 | 5,000 | 5,000 |
| Government | 169,800 | 22,300 | 105,700 | 70,600 | 11,600 | 2,500 | 1,100 | 19,900 | 19,500 | 22,300 |
| Federal Government | 78,700 | 5,500 | 54,700 | 30,200 | 7,200 | 2,500 | 700 | 14,100 | 13,300 | 5,200 |
| State governments | 59,400 | 6,500 | 31,700 | 25,100 | 2,700 | --- | 200 | 3,600 | 5,500 | 15,700 |
| Local governments | 31,600 | 10,300 | 19,300 | 15,300 | 1,700 | --- | 100 | 2,200 | 700 | 1,400 |
| Colleges and universities | 10,000 | 2,000 | 4,300 | 1,000 | 1,500 | 700 | 300 | 800 | 3,700 | 100 |

1/ Less than 50 cases.

Note: Because of rounding, the sum of individual items may not equal totals.

Source: Bureau of Labor Statistics

## Table A-2. Estimated Employment of Scientists and Engineers, by Occupation and Industry, 1963

| Industry | Total scientists and engineers | Engineers | Scientists | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total | Chemists | Physicists | Mathematicians | Life scientists | Other scientists 2/ |
| All Industries | 1,271,600 | 924,900 | 346,800 | 107,500 | 36,100 | 42,100 | 112,100 | 49,000 |
| Mining (including petroleum) | 28,300 | 18,000 | 10,200 | 1,200 | 100 | 100 | 300 | 8,600 |
| Construction | 49,100 | 48,300 | 800 | 100 | (1/) | 600 | (1/) | 100 |
| | | | | | | | | |
| Manufacturing | 635,200 | 510,600 | 124,500 | 65,900 | 11,000 | 12,600 | 17,600 | 17,500 |
| Ordnance and accessories | 52,900 | 46,200 | 6,600 | 1,100 | 2,200 | 2,100 | 600 | 600 |
| Food and kindred products | 13,100 | 5,900 | 7,200 | 4,100 | (1/) | 100 | 3,000 | 100 |
| Textile mill products and apparel | 4,300 | 2,900 | 1,400 | 1,300 | (1/) | (1/) | (1/) | (1/) |
| Lumber and furniture | 4,800 | 3,400 | 1,500 | 700 | (1/) | (1/) | 700 | (1/) |
| Paper and allied products | 13,700 | 9,700 | 4,000 | 3,000 | (1/) | 200 | 700 | 100 |
| Chemicals and allied products | 85,100 | 34,600 | 50,600 | 35,300 | 1,200 | 900 | 11,100 | 2,100 |
| Petroleum refining and products of petroleum and coal | 15,100 | 9,600 | 5,400 | 3,800 | 100 | 200 | 100 | 1,300 |
| Rubber products | 8,000 | 5,800 | 2,200 | 1,900 | 100 | 100 | (1/) | 100 |
| Stone, clay, and glass products | 10,100 | 8,000 | 2,100 | 1,700 | 200 | 100 | (1/) | 100 |
| Primary metal products | 29,800 | 20,300 | 9,500 | 2,500 | 100 | 200 | 100 | 6,500 |
| Fabricated metal products | 27,800 | 24,700 | 3,000 | 900 | 300 | 600 | 700 | 500 |
| Machinery, except electrical | 75,400 | 69,600 | 5,800 | 1,400 | 900 | 2,200 | 100 | 1,100 |
| Electrical equipment | 146,200 | 135,900 | 10,300 | 2,700 | 3,400 | 2,600 | 100 | 1,400 |
| Aircraft and parts | 83,000 | 76,100 | 6,900 | 1,400 | 1,100 | 2,600 | 200 | 1,600 |
| Motor vehicles and equipment | 18,000 | 16,400 | 1,600 | 500 | 100 | 300 | (1/) | 700 |
| Other transportation equipment | 7,000 | 6,800 | 300 | 100 | (1/) | 100 | --- | 100 |
| Professional and scientific instruments | 32,500 | 27,800 | 4,600 | 2,200 | 1,100 | 300 | 200 | 800 |
| Miscellaneous manufacturing | 8,500 | 6,800 | 1,700 | 1,300 | 100 | 100 | 100 | 100 |
| | | | | | | | | |
| Transportation, communication, and electric, gas, and sanitary services | 47,200 | 45,500 | 1,700 | 600 | (1/) | 400 | 200 | 500 |
| Transportation | 9,600 | 9,100 | 500 | 300 | (1/) | 100 | 100 | 100 |
| Communication | 13,000 | 12,900 | 100 | (1) | (1/) | 100 | --- | (1/) |
| Electric, gas, and sanitary services | 24,700 | 23,600 | 1,100 | 300 | (1/) | 300 | 100 | 400 |
| | | | | | | | | |
| Other industries | 183,800 | 141,800 | 42,000 | 12,600 | 5,200 | 9,100 | 8,700 | 6,400 |
| Miscellaneous business services | 52,000 | 33,800 | 18,200 | 6,100 | 2,800 | 3,200 | 1,700 | 4,400 |
| Medical and dental laboratories | 1,100 | --- | 1,100 | 200 | --- | --- | 900 | --- |
| Nonprofit organizations | 13,100 | 3,600 | 9,500 | 3,300 | 1,200 | 500 | 3,600 | 900 |
| Engineering and architectural services | 79,200 | 76,900 | 2,300 | 400 | 600 | 600 | (1/) | 700 |
| All other nonmanufacturing | 38,400 | 27,500 | 10,900 | 2,600 | 600 | 4,800 | 2,500 | 400 |
| | | | | | | | | |
| Government | 199,800 | 132,800 | 67,000 | 9,900 | 4,900 | 3,200 | 38,300 | 10,700 |
| Federal Government | 118,000 | 71,700 | 46,300 | 7,000 | 4,900 | 2,800 | 22,300 | 9,300 |
| State governments | 47,900 | 34,200 | 13,700 | 1,400 | --- | 300 | 10,800 | 1,200 |
| Local governments | 33,900 | 26,900 | 7,000 | 1,500 | --- | 100 | 5,200 | 200 |
| | | | | | | | | |
| Colleges and Universities | 128,200 | 27,700 | 100,500 | 17,200 | 14,900 | 16,200 | 47,000 | 5,200 |

1/ Less than 50 cases.
2/ Includes geologists, geophysicists, metallurgists, and other physical scientists.

Note: Because of rounding, the sum of individual items may not equal totals.

Source: Bureau of Labor Statistics

Table A-3. Intermediate Projections of 1975 Requirements for Technicians, by Occupation and Industry

| Industry | Total technicians | Draftsmen | Engineering and physical science technicians | | | | | | Life science technicians | All other technicians |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Engineering technicians | Chemical technicians | Physics technicians | Mathematics technicians | Other physical science technicians | | |
| All Industries | 1,494,900 | 375,400 | 770,100 | 532,600 | 122,500 | 21,700 | 11,900 | 81,400 | 139,200 | 210,200 |
| Mining (including petroleum) | 19,900 | 5,500 | 9,800 | 3,400 | 600 | 100 | (1/) | 5,700 | (1/) | 4,500 |
| Construction | 52,900 | 23,300 | 20,700 | 19,300 | 600 | 300 | 200 | 400 | 200 | 8,700 |
| Manufacturing | 621,900 | 182,900 | 340,700 | 240,100 | 61,800 | 8,700 | 3,700 | 26,400 | 15,000 | 83,300 |
| Ordnance and accessories | 22,600 | 4,900 | 15,500 | 12,400 | 1,100 | 800 | 300 | 800 | (1/) | 2,200 |
| Food and kindred products | 15,100 | 900 | 8,200 | 3,000 | 4,500 | 500 | 100 | 200 | 2,800 | 3,200 |
| Textile mill products and apparel | 5,300 | 400 | 2,700 | 1,200 | 1,300 | (1/) | (1/) | 100 | 100 | 2,100 |
| Lumber and furniture | 12,600 | 5,700 | 2,400 | 1,600 | 700 | (1/) | (1/) | 100 | 600 | 4,000 |
| Paper and allied products | 11,000 | 3,100 | 6,100 | 3,500 | 2,100 | 200 | 100 | 200 | 200 | 1,600 |
| Chemicals and allied products | 75,800 | 6,000 | 48,700 | 13,600 | 30,400 | 800 | 400 | 3,600 | 8,600 | 12,400 |
| Petroleum refining and products of petroleum and coal | 9,000 | 1,400 | 5,800 | 2,400 | 2,000 | 100 | 100 | 1,200 | 100 | 1,900 |
| Rubber products | 10,300 | 2,500 | 5,800 | 3,200 | 2,100 | 100 | (1) | 300 | 100 | 1,900 |
| Stone, clay, and glass products | 8,400 | 2,100 | 4,100 | 2,600 | 1,200 | 100 | (1) | 200 | (1/) | 2,300 |
| Primary metal products | 24,500 | 5,800 | 14,600 | 6,100 | 2,000 | 400 | 100 | 6,100 | 200 | 3,900 |
| Fabricated metal products | 43,800 | 26,800 | 11,700 | 9,600 | 900 | 200 | 100 | 800 | 100 | 5,300 |
| Machinery, except electrical | 93,300 | 40,900 | 40,200 | 34,600 | 2,200 | 700 | 600 | 2,000 | 200 | 12,000 |
| Electrical equipment | 163,700 | 42,300 | 108,900 | 93,400 | 6,300 | 3,100 | 1,000 | 5,100 | 100 | 12,500 |
| Aircraft and parts | 48,000 | 11,500 | 31,100 | 26,100 | 1,500 | 600 | 500 | 2,400 | 100 | 5,300 |
| Motor vehicles and equipment | 22,800 | 9,800 | 9,200 | 7,200 | 600 | 100 | 100 | 1,200 | --- | 3,700 |
| Other transportation equipment | 10,700 | 7,000 | 3,300 | 2,900 | 100 | (1/) | (1/) | 100 | --- | 500 |
| Professional and scientific instruments | 38,700 | 9,000 | 20,600 | 15,300 | 2,600 | 700 | 200 | 1,900 | 1,900 | 7,200 |
| Miscellaneous manufacturing | 6,300 | 2,900 | 1,800 | 1,500 | 10,000 | (1/) | (1/) | 100 | 100 | 1,500 |
| Transportation, communication, and electric, gas, and sanitary services | 71,400 | 9,400 | 48,600 | 44,600 | 1,600 | 400 | 300 | 1,600 | 300 | 13,100 |
| Transportation | 11,900 | 2,800 | 5,800 | 4,900 | 500 | 100 | (1) | 300 | 100 | 3,200 |
| Communication | 37,900 | 1,000 | 30,600 | 28,900 | 600 | 400 | 200 | 600 | --- | 6,400 |
| Electric, gas, and sanitary services | 21,600 | 5,600 | 12,200 | 10,700 | 600 | --- | 100 | 800 | 200 | 3,500 |
| Other Industries | 373,700 | 104,400 | 141,500 | 86,000 | 31,400 | 6,300 | 4,900 | 12,900 | 76,900 | 50,900 |
| Miscellaneous business services | 95,400 | 25,700 | 50,800 | 31,600 | 9,900 | 2,600 | 1,400 | 5,200 | 2,700 | 16,100 |
| Medical and dental laboratories | 57,100 | --- | 100 | --- | 100 | --- | --- | --- | 55,600 | 1,400 |
| Nonprofit organizations | 34,300 | 3,800 | 20,700 | 4,500 | 9,600 | 2,000 | 500 | 4,100 | 9,600 | 100 |
| Engineering and architectural services | 115,000 | 69,700 | 21,100 | 18,000 | 800 | 500 | 400 | 1,300 | 100 | 24,100 |
| All other nonmanufacturing | 71,900 | 5,100 | 48,700 | 31,800 | 11,000 | 1,100 | 2,500 | 2,300 | 8,900 | 9,100 |
| Government | 327,800 | 44,800 | 196,900 | 136,300 | 22,200 | 4,100 | 2,000 | 32,200 | 36,500 | 49,600 |
| Federal Government | 127,700 | 8,100 | 89,400 | 49,400 | 11,700 | 4,100 | 1,100 | 23,000 | 21,700 | 8,500 |
| State governments | 137,800 | 14,300 | 72,500 | 56,800 | 6,500 | --- | 600 | 8,700 | 13,200 | 37,800 |
| Local governments | 62,400 | 22,500 | 35,000 | 30,100 | 4,100 | --- | 300 | 500 | 1,600 | 3,300 |
| Colleges and Universities | 27,300 | 5,000 | 11,900 | 2,900 | 4,100 | 1,800 | 900 | 2,200 | 10,200 | 100 |

1/ Less than 50 cases.

Note: Because of rounding, the sum of individual items may not equal totals.

Source: Bureau of Labor Statistics

### Table A-4. Projected 1975 Requirements for Scientists and Engineers, by Occupation and Industry

| Industry | Total scientists and engineers | Engineers | Scientists | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total | Chemists | Physicists | Mathematicians | Life scientists | Other scientists 2/ |
| All Industries | 2,119,400 | 1,466,500 | 652,900 | 194,700 | 71,900 | 87,500 | 222,300 | 76,600 |
| Mining (including petroleum) | 38,300 | 24,800 | 13,500 | 1,500 | 100 | 100 | 400 | 11,400 |
| Construction | 83,800 | 82,500 | 1,300 | 200 | (1/) | 1,000 | (1/) | 100 |
| Manufacturing | 942,500 | 746,200 | 196,300 | 108,000 | 17,200 | 19,100 | 28,200 | 23,800 |
| Ordnance and accessories | 57,500 | 49,400 | 8,100 | 1,400 | 2,900 | 2,600 | 600 | 700 |
| Food and kindred products | 16,200 | 7,300 | 8,900 | 5,300 | 100 | 200 | 3,200 | 100 |
| Textile mill products and apparel | 7,000 | 4,500 | 2,500 | 2,400 | (1/) | (1/) | (1/) | (1/) |
| Lumber and furniture | 6,400 | 4,400 | 2,000 | 900 | (1/) | (1/) | 900 | (1/) |
| Paper and allied products | 21,900 | 15,600 | 6,300 | 4,600 | 200 | 400 | 1,000 | 100 |
| Chemicals and allied products | 154,100 | 62,600 | 91,600 | 64,000 | 2,000 | 1,900 | 20,200 | 3,500 |
| Petroleum refining and products of petroleum and coal | 18,700 | 11,900 | 6,800 | 4,700 | 200 | 300 | 100 | 1,600 |
| Rubber products | 13,800 | 10,000 | 3,800 | 3,300 | 100 | 100 | (1/) | 200 |
| Stone, clay, and glass products | 13,800 | 10,900 | 2,900 | 2,300 | 300 | 100 | (1/) | 200 |
| Primary metal products | 41,300 | 28,600 | 12,700 | 3,700 | 400 | 400 | 100 | 8,000 |
| Fabricated metal products | 44,500 | 39,700 | 4,900 | 1,400 | 500 | 1,000 | 1,100 | 800 |
| Machinery, except electrical | 108,700 | 100,400 | 8,300 | 2,000 | 1,300 | 3,500 | 200 | 1,300 |
| Electrical equipment | 226,000 | 210,200 | 15,800 | 4,300 | 5,400 | 3,800 | (1) | 2,200 |
| Aircraft and parts | 105,800 | 96,900 | 8,900 | 1,600 | 1,500 | 3,500 | 200 | 2,100 |
| Motor vehicles and equipment | 29,200 | 26,600 | 2,600 | 800 | 200 | 500 | --- | 1,200 |
| Other transportation equipment | 11,000 | 10,600 | 400 | 100 | (1/) | 100 | --- | 100 |
| Professional and scientific instruments | 56,600 | 48,600 | 8,000 | 3,600 | 1,900 | 700 | 400 | 1,500 |
| Miscellaneous manufacturing | 10,100 | 8,100 | 2,000 | 1,600 | 100 | 100 | 100 | 100 |
| Transportation, communication, and electric, gas, and sanitary services | 56,200 | 54,100 | 2,100 | 800 | (1/) | 500 | 200 | 600 |
| Transportation | 12,900 | 12,200 | 800 | 400 | (1/) | 100 | 100 | 100 |
| Communication | 15,400 | 15,300 | 100 | (1/) | (1/) | 100 | --- | (1/) |
| Electric, gas, and sanitary services | 27,900 | 26,600 | 1,300 | 400 | --- | 300 | 100 | 400 |
| Other industries | 346,700 | 254,600 | 92,000 | 27,500 | 11,800 | 19,100 | 19,700 | 14,000 |
| Miscellaneous business services | 118,500 | 77,000 | 41,400 | 14,000 | 6,300 | 7,300 | 3,800 | 10,000 |
| Medical and dental laboratories | 3,600 | --- | 3,600 | 600 | --- | --- | 3,000 | --- |
| Nonprofit organizations | 31,800 | 8,700 | 23,100 | 7,900 | 3,000 | 1,300 | 8,800 | 2,100 |
| Engineering and architectural services | 129,900 | 123,800 | 6,100 | 600 | 1,400 | 2,600 | 100 | 1,300 |
| All other nonmanufacturing | 62,900 | 45,100 | 17,800 | 4,300 | 1,000 | 7,800 | 4,000 | 600 |
| Government | 353,600 | 239,900 | 113,700 | 16,700 | 7,300 | 5,000 | 67,900 | 16,900 |
| Federal Government | 175,000 | 106,400 | 68,600 | 10,300 | 7,300 | 4,100 | 33,100 | 13,800 |
| State governments | 104,600 | 74,700 | 29,900 | 3,000 | --- | 700 | 23,600 | 2,600 |
| Local governments | 74,000 | 58,800 | 15,200 | 3,300 | --- | 200 | 11,300 | 400 |
| Colleges and Universities | 298,300 | 64,400 | 233,800 | 40,100 | 35,400 | 42,600 | 105,800 | 9,800 |

1/ Less than 50 cases.

2/ Includes geologists, geophysicists, metallurgists, and other physical scientists.

Note: Because of rounding, the sum of individual items may not equal totals.

Source: Bureau of Labor Statistics

# Appendix B. Derivation of 1963 Employment of Scientists, Engineers, and Technicians

This appendix describes the methods used to develop the estimates of 1963 employment of technicians, scientists, and engineers, by occupation, used in this report. It presents the sources of the basic data, and illustrates some of the problems that had to be overcome in order to develop adequate estimates. In general, similar methods were used to derive the estimates for technicians and for scientists and engineers.

## Methodology

Employment estimates were developed separately for scientists and engineers and for technicians, in the greatest occupational detail possible from available information on a national scale. The basic data utilized were the most current available on employment in each sector of the economy--private industry, colleges and universities, Federal Government, State governments, local governments, and nonprofit organizations not covered in the college and university sector. For most sectors, the most recent statistics were for 1963 employment, but in those sectors where such data were not available, the most current information available was used for a base year, and the data updated to 1963. In instances where updating of the information was required, among the factors taken into account were historical trends in the employment of scientists, engineers, and technicians; research and development expenditures; and other related factors. Because the occupational detail in some of the sources of data differed, it was necessary to make additional adjustments to maintain comparability of data. The estimates developed for each economic sector were then aggregated to obtain estimates of employment in the economy as a whole. The following section describes the methods used to develop 1963 employment in each sector.

Private Industry. Employment in private industry was based primarily on preliminary data from the Bureau of Labor Statistics' survey, Employment of Scientific and Technical Personnel in Industry, 1963 (STP). 1/ Problems related to the overall coverage of the STP survey had to be resolved because it excluded companies below specified sizes; for example, the large number of contract construction companies with 10 or fewer employees were excluded from the survey. Estimates thus were made of the number of scientists, engineers, and technicians in these and other firms not included in the STP survey coverage.

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1/ The survey reported employment as of January 1963. Since by far the largest number of technicians are employed in private industry, estimated employment in all other sectors was adjusted, where necessary, to this early 1963 date.

Colleges and Universities. The primary source of data for college and university employment of scientists, engineers, and technicians was a survey of college and university employment in 1961 conducted by the National Science Foundation. 2/ The 1961 employment data were adjusted to reflect estimated 1961-63 changes in employment, primarily on the basis of trends in enrollments in colleges and universities and in research and development expenditures in these institutions. Because the 1961 data covered both full- and part-time employees, it was necessary to adjust the data to eliminate double counting of part-time employees who are employed (and counted) in other sectors of the economy. 3/

Technicians in colleges and universities are believed to be employed nearly exclusively in research and development activities. As a result, technician employment estimates were based primarily on estimates of the number of supporting persons needed by scientists and engineers employed in Federal Contract Research Centers and agricultural experiment stations. Such estimates were based on an analysis of the number of technicians for each scientist and engineer employed in other organizations similarly engaged primarily in research. No estimate of technician employment was made for college and universities proper, even though a great deal of research is conducted in these institutions, since evidence indicates that graduate students do most of the technician work in support of scientists and engineers.

Federal Government. The primary source of employment data on scientists, engineers, and technicians employed by the Federal Government was a study conducted by the Civil Service Commission, which reported employment in the Federal Government as of October 31, 1962. 4/ A detailed analysis was made of each occupational category to assure comparability with the various occupational categories used in the STP surveys. The October 1962 statistics were adjusted to early 1963, based on the change in total Federal employment during the latter months of 1962 and taking into account changes in employment in the technician occupations during the preceeding year.

State Government. The main source of data on State government employment of scientists, engineers, and technicians was the Bureau of Labor Statistics survey, Employment of Scientific and Technical Personnel in State Government Agencies, 1962. 5/ The 1962 data were updated to 1963

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2/ Science and Engineering Professional Manpower Research in Colleges and Universities, 1961. In this survey, colleges and universities include not only colleges and universities proper, but also agricultural experiment stations and Federal contract research centers administrated by colleges and universities.

3/ For example, chemists who were employed in private industry in 1961 and were also teaching part time in a college or university would be included in both sectors unless these adjustments were made.

4/ Scientific and Technical Personnel in the Federal Government, 1961 and 1962 (National Science Foundation) NSF 65-4.

5/ Op. cit.

on the basis of historical trends in State employment of scientists, engineers, and technicians between 1959 and 1962; 6/ trends in total State government employment and expenditures; and upon an analysis of other factors, such as employment in State highway departments.

*Local Government*. Data on the employment of scientists, engineers, and technicians in local government are extremely limited. Basically, the employment totals reflect information from an unpublished Bureau of Labor Statistics pilot survey covering January 1960 scientific and technical employment in local government agencies in six States. The data on scientific and technical employment in the pilot survey were analyzed and related to total employment in the local governments surveyed in order to develop ratios of scientific and technical employment to total employment. These ratios were applied to 1960 employment in local government in all States to derive an estimate of total 1960 scientific and technical employment. These data were then updated to 1963 on the basis of available information on the trends in employment and factors affecting employment in local governments between 1960 and 1963. Although the estimates of employment in this sector are believed to be relatively weak, the small number involved does not affect the total estimate significantly.

*Nonprofit Organizations*. This sector of the economy is more correctly called "other nonprofit organizations" since it excludes nonprofit groups covered in the National Science Foundation surveys of college and university employment previously discussed. The organizations covered in this sector include foundations, health agencies, research institutions, certain research centers, science museums, zoological and botantical gardens, and arboretums. Employment statistics are based on two reports published by the National Science Foundation, *Scientific Research and Development of Nonprofit Organizations, Expenditures and Manpower, 1953*, NSF 61-37, and *Research and Other Activities of Private Foundations*, (Report on 1960 Employment) NSF 64-14.

In general, these reports did not provide the desired occupational information, and many adjustments had to be made in order to develop the necessary occupational statistics. Furthermore, many assumptions had to be made to update the statistics to reflect 1963 employment, mostly relating to growth in research and development expenditures in this sector of the economy in the recent period.

*Occupational Detail*. The occupational distribution generally available for technician occupations--draftsmen, engineering and physical science technicians, life science technicians, and other technicians--did not provide the detail needed for an adequate analysis of the occupation for this report.

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6/ Comparable data were available for 1959 in another survey of State Governments conducted by the Bureau of Labor Statistics for the National Science Foundation, *Employment of Scientific and Technical Personnel in State Government Agencies, Report on a 1959 Survey* (National Science Foundation), NSF 61-17.

To develop an improved occupational distribution for technicians comparable to the detail for scientists and engineers on which the projections were based, data from the Postcensal Study of Professional and Technical Manpower on the field of specialization of technicians were used. These data were used to break down the broad group "engineering and physical science technicians" into engineering technicians, physics technicians, mathematics technicians, chemical technicians, and other physical technicians.

Comparison of BLS and Postcensal Data. Before using the data from the Postcensal Survey to develop an occupational distribution and to describe the characteristics of technicians, 7/ it was necessary to assure comparability of the coverage of the Postcensal Study with that of this report. The workers included as technicians in the Postcensal Study were draftsmen, electronic and electrical technicians, other engineering and physical science technicians, technicians, n.e.c., surveyors, designers, and medical and dental technicians. An analysis of the Postcensal data on these occupations indicated that, in addition to the workers counted as technicians in this report, the Postcensal Study included designers such as clothes and fashion designers, 8/ who could not be broken out of the total group of designers. Despite the inclusion of the relatively small number of these workers, it is believed that comparability is great enough to permit the use of Postcensal data to develop a meaningful occupational distribution of engineering and physical science technicians and to develop data on the characteristics of technicians. However, in analyzing the characteristics of technicians in the "other" technician group (the group including designers) care should be used. Inclusion of all designers is not to affect significantly characteristics of total technicians, because of the small number of such workers involved.

To further check the comparability, a comparison was made of this total number of workers in the BLS employment estimate prepared for the report with a related estimate from the Postcensal Study. 9/ Although the Postcensal estimate was slightly lower than the BLS estimate, the relationship was close enough to ensure rough comparability, particularly in view of the differences in the methods of data collection and the lack of a universally accepted definition of technician.

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7/ The characteristics of technicians are presented in chapter II.

8/ Some designers are included as technicians in this report, such as those assisting scientists and engineers in designing machine tools.

9/ Excluded from the Postcensal Study those medical and dental technicians engaged in patient care, and designers in several industries.

## Appendix C. Sample Technician Training Programs

The following tables present a typical curriculum in each of the formal types of training designed to train technicians--high school, post secondary preemployment, industry, Armed Forces, and training under the Manpower Development and Training Act. These illustrations are not meant to imply acceptance or approval by the Bureau of Labor Statistics or any other Federal agency, and are not meant to indicate that these programs are either the best or most often used. They are presented merely to illustrate the type of program offered in each source of training.

Table C-1. Three-Year High School Mechanical Technology Curriculum

| Course, by grade | Periods per week 1/ | Hours per week |
|---|---|---|
| Tenth grade | | |
| English | 5 | 3.75 |
| Mathematics | 5 | 3.75 |
| Mechanical drawings | 10 | 7.50 |
| Machine shop theory and practice | 10 | 7.50 |
| Elective | 5 | 3.75 |
| Health | 5 | 3.75 |
| Eleventh grade | | |
| English | 5 | 3.75 |
| World history | 5 | 3.75 |
| Mathematics | 5 | 3.75 |
| Chemistry | 5 | 3.75 |
| Mechanical drawing | 10 | 7.50 |
| Machine shop theory and practice | 5 | 3.75 |
| Twelfth grade | | |
| English | 5 | 3.75 |
| American history | 5 | 3.75 |
| Mathematics | 5 | 3.75 |
| Technical physics | 10 | 7.50 |
| Metallurgy | 5 | 3.75 |
| Machine design | 5 | 3.75 |
| Elective | 5 | 3.75 |

| | Contact hours |
|---|---|
| Technical courses | 1,350 |
| Mathematics | 405 |
| Science | 405 |
| General education | 1,080 |
| Total | 3,240 |

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1/ 45-minute periods, 36-week semesters.

Source: Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs, U.S. Department of Health, Education, and Welfare, Office of Education (OE-80015).

Table C-2. Two-Year Post-Secondary Mechanical Technology Curriculum

(72 credit hours)

| Course, by term | Credit hours |
|---|---|
| **First year** | |
| First term | 18 |
| Orientation | 0 |
| Materials of industry | 3 |
| Mechanical drafting I | 4 |
| Manufacturing processes I | 3 |
| Mathematics I | 5 |
| Communication skills | 3 |
| Second term | 18 |
| Technical reporting | 2 |
| Manufacturing processes II | 3 |
| Mechanical drafting II | 4 |
| Mathematics II | 4 |
| Mechanics and heat | 5 |
| **Second year** | |
| Third term | 18 |
| Strength of materials | 4 |
| Basic mechanisms | 5 |
| Electricity | 4 |
| American institutions | 2 |
| Hydraulics and pneumatics | 3 |
| Fourth term | 18 |
| Machine design | 3 |
| Basic tool design | 4 |
| Design problems | 5 |
| Psychology and human relations | 3 |
| Industrial organizations and institutions | 3 |

Source: Mechanical Technology-Design and Productions, A Suggested 2-Year Post-Secondary Curriculum (U.S. Department of Health, Education, and Welfare, Office of Education, Technical Education Program Series No. 3, 1962).

Table C-3. MDTA Training Program for Occupation of Draftsman

| Units | Hours |
|---|---|
| Total hours | 1,440 |
| **Part I. Elementary** | |
| 1. Use of instruments, orthographic projection, and elementary dimensioning | 15 |
| 2. Lettering | 75 |
| 3. Applied geometry | 50 |
| 4. Working drawings | 150 |
| 5. Tracing and reproduction of drawings | 90 |
| **Part II. Intermediate** | |
| 1. Auxiliaries | 120 |
| 2. Helical forms and fastenings | 120 |
| 3. Sectional views | 75 |
| 4. Systems of dimensioning and fits and tolerances | 120 |
| 5. Freehand technical sketching | 100 |
| 6. Isometric drawing | 75 |
| **Part III. Machine drawing problems** | |
| 1. Welding drawing | 75 |
| 2. Piping | 50 |
| 3. Cams | 75 |
| 4. Bearings | 75 |
| 5. Gearing | 100 |
| 6. Structural drawings | 75 |

Source: U.S. Department of Labor, Office of Manpower, Automation, and Training (Unpublished data).

Table C-4. Apprenticeship Training Program for Occupation of Draftsman

| Draftsman | Approximate months | Credit hours |
|---|---|---|
| Work Schedule | 48 | |
| Training | 3 | |
| Routine department work | 3 | |
| Detailing | 12 | |
| Engineering changes | 12 | |
| Simple assembly drawings | 12 | |
| Subassembly drawings | 6 | |
| Related instruction | | 495 |
| Machine shop practice | | 72 |
| Drafting | | 54 |
| Detail design | | 27 |
| Algebra | | 81 |
| Technical illustration | | 27 |
| Descriptive geometry | | 54 |
| Trigonometry | | 45 |
| Analytical geometry | | 45 |
| Elementary statistics | | 45 |
| Elementary strength of materials | | 45 |

Source: Apprenticeship and Training Standards for Draftsmen (U.S. Department of Labor, Bureau of Apprenticeship and Training, 1960).

Table C-5. Company Training Program for Technicians

| Course | Number of hours |
|---|---|
| Total hours | 509 |
| Company organization | 4 |
| Company products | 12 |
| Plant and office arrangement | 20 |
| Company procedures--departmental functions | 10 |
| Engineering math | 120 |
| Blueprint reading | 40 |
| Curve plotting | 15 |
| Shop sketching | 18 |
| Drafting and engineering standards | 80 |
| Industrial testing | 40 |
| Cost analysis | 12 |
| Human relations | 8 |
| Basic electricity | 48 |
| Office machines | 16 |
| Communications | 8 |
| Business English | 50 |
| Better methods | 8 |

Source: Hardman, William E., In-Plant Training (Waterford, Conn., Prentice-Hall, Inc., 1964).

Table C-6. Army Training Course for Occupation of Electronic Equipment Technician

A. Introduction to communication
B. Supply procedures
C. Electrical fundamentals
D. Electronics
E. Oscillator--amplifier circuiting
F. Nonsinusoidel circuitry
G. Time indicator components
H. Microwave transmitters
I. Modulators and receivers
J. Servo and data circuitry
K. Finders, analyzers, recorders, search and intercept receivers
L. Communication radar and VT fuse countermeasures equipment

Source: The Army School Catalog (Department of Army Course 11-R-283.1, August, 1962).

Table C-7. Correspondence Training Program for Occupation of Electronic Technician

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Basic Subjects:

Fundamentals of electricity
Refresher mathematics
Report writing
Science for technicians
Shop sketching--freehand
Electronic test equipment, theory, and use
Slide rule
Transistors in radio, television, and electronics
How to talk more effectively

(Basic subject with one of the following options takes an average of 700-800 hours of study.)

Option "A"--Communication

Closed-circuit and industrial television
Industrial sound systems
Magnetic recording, techniques of
Electronic communication

Option "B"--Industrial electronics

Electronics, elementary industrial
Automation in practice
Magnetic amplifiers
Computers and how they work
Instrumentation

Option "C"--Electronic drafting

Drafting, elementary
Electronics, elementary industrial
Electrical and electronic drawing
Manufacturing processes

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Source: Published in Some of the Technical Courses Offered by Accredited Private Home Study Schools, National Home Study Council.

## Appendix D. Selected Bibliography

This bibliography lists a selected group of the reprints, books, and articles published in recent years on subjects relating to technician manpower. However, because of space limitations, no attempt has been made to include all the many fine studies published. The selected material is separated into 4 sections: (I) Federal Government publications, by agency; (II) State and Local Government publications; (III) Individual books and reports by non-government organizations; and (IV) Periodicals.

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*Careers for Women as Technicians.* Women's Bureau, Bulletin 282, 1961.

"The Changing Pattern of Military Skills," *Employment Security Review*, July 1963. (Bureau of Employment Security), pp. 27-32.

*Current Labor Market Conditions in Engineering, Scientific, and Technical Occupations* (series). Bureau of Employment Security, 1965.

"Education and Training of Technicians," *Monthly Labor Review*, 1964, pp. 1279-1280.

*Employment of Scientific and Technical Personnel in Industry, 1962.* BLS Bulletin 1418, 1964.

*Formal Occupational Training of Adult Workers--Extent, Nature, and Use, April 1963.* Manpower Administration, Office of Manpower, Automation and Training, 1964.

*Manpower Report of the President and A Report on Manpower Requirement, Resources, Utilization, and Training by the U.S. Department of Labor.* Transmitted to the Congress, March 1966.

*Manpower Research and Training Under the Manpower Development and Training Act of 1962.* A report of the Secretary of Labor transmitted to Congress, March 1966.

*The Mobility of Electronic Technicians.* BLS Bulletin 1150, 1954.

"Professional Service for the Technician," *Employment Security Review*, April 1964. (Bureau of Employment Security), pp. 31-32.

"Technician Occupations," *Occupational Outlook Handbook*, 1966-67, 7th edition. BLS Bulletin 1450, pp. 220-228.

*The Training of Workers in American Industry.* Bureau of Apprenticeship and Training, 1964.

### B. U.S. Department of Health, Education, and Welfare, Office of Education

*Determining Requirements for Development of Technical Abilities Through Extension Courses*, OE 80010, 1961

*Directory of Schools Offering Technical Education Programs Under Title VIII of the National Defense Education Act of 1958*, Fiscal Year 1964. February 1965.

*Guide to Organized Occupational Curriculums in Higher Education*, OE 54012-62, 1965.

*Education for a Changing World of Work - Appendix I: Technical Training in the United States*, OE 80022, 1964.

*Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs*, OE 80015, 1962.

*Progress in Title VIII Programs*, Fiscal Years 1959-1964.

*Scientific and Technical Societies Pertinent to the Education of Technicians*, OE 80037, 1965.

"Technician Education: A Challenge to American Educators," *School Life*, May 1961, pp. 24-25.

*Vocational-Technical Education for American Industry*, Circular No. 530, 1958.

*Suggested 2-Year Post-High School Curriculum* in:

| | | |
|---|---|---|
| Electrical Technology | -- | OE 80006 |
| Electronic Technology | -- | OE 80009 |
| Mechanical Technology-Design & Production | -- | OE 80019 |
| Electronic Data Processing I | -- | OE 80024 |
| Chemical Technology | -- | OE 80031 |
| Instrumentation Technology | -- | OE 80033 |

Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs

Mechanical Drafting and Design Technology -- OE 80000
Electrical and Electronic Technology -- OE 80004
Mechanical Technology-Design and Production -- OE 80014
Chemical and Metallurgical Technologies -- OE 80016
Civil and Highway Technology -- OE 80018
Electronic Data Processing in Engineering, Science and Business -- OE 80030

The 2-Year Community College: An Annotated List of Unpublished Studies and Surveys, 1957-61, OE 57005

### C. The Congress of the United States

Hearings before the Subcommittee on Education of the Committee on Labor and Public Welfare, United States Senate, 88th Congress, First Session, Vol. III. May 27, 28, and 29, 1963. pp. 1534-1559.

### D. Other Government Agencies

Handbook of Occupational Groups and Series of Classes Established Under the Federal Position-Classification Plan, Civil Service Commission, Bureau of Programs and Standards Division, March 1963.

Scientists, Engineers, and Technicians in the 1960's--Requirements and Supply. National Science Foundation (NSF, 63-64) 1963.

Scientific and Technical Manpower Resources. National Science Foundation (NSF, 64-28) 1964.

Toward Better Utilization of Scientific and Engineering Talent: A Program for Action. Committee on Utilization of Scientific and Engineering Manpower, Washington, D.C., 1964.

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The Profile of Michigan Manpower Training Needs of the 1960's. Department of Public Instruction, Lansing, 1962.

Report of a Survey of the Need for Technicians in the Automotive Manufacuring Industry in the Detroit Metropolitan Area. Detroit Board of Education, 1962.

Report of Utah's Technical Manpower Survey for Training Requirements (series). Utah Department of Employment Security, Salt Lake City, 1958 and 1960.

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